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1. General Specification

1.1 General Information

1.1.1 Project Description

In January 11, 2012, the Natural Resources Authority of Rwanda ("RNRA") requested the KOICA office in Rwanda to perform the consulting services of Feasibility Study ("F/S") and Detailed Design ("D/D") for a Multipurpose Dam Development Work, which can bring diverse benefits such as stable water supply, flood controlling functions, fish farming, tourism attraction, and hydroelectric energy production as well, in Nyagatare City (located in eastern Rwanda).

According to the "Rwanda Vision 2020," which is aimed at achieving the national goal of becoming a middle-income country by 2020, Rwanda will witness a 1.6 times of population growth to reach 16 million by the same target year of 2020, which indicates that an increase in municipal, agricultural and industrial water consumption and demand is inevitable for that corresponding period.

Actually, the country has a relatively sufficient amount of water resources. However, per capita water availability is far short of meeting the water supply demand from the Rwandans due to the high population density. The nation-wide water supply rate is just as low as 54%, and the rate of water supply stands at lower than 44% in rural areas. Especially, in Nyagatare City where the project area is situated, the electricity and water supply rate is 15% or lower. This is why it is required to develop a multipurpose dam as one of the fundamental solutions to solve the water and electricity shortages, to supply water and electricity in a reliable manner and to realize a fair distribution of water resources, which will be fundamentally helpful in narrowing the substantial gap between the rich and the poor. In this study, the Consultant has planned to invite some of relevant personnel of Rwanda to Korea in order to transfer advanced water resource technologies and techniques required to operate and maintain relevant hydraulic structures and facilities, contributing to the sustainable development of the Rwandan society and economy.

1.1.2 Project Location and Site Access

As a landlocked country in East Africa, Nyagatare District is situated in the Eastern Province. The Muvumba river, the target basin area, belongs to the Nile R. basin and is located 10km upstream of Nyagatare town.
### Scale of Project Development (Summary)

- Maximum water level (M.W.L) : EL. 1,406.6m
- Flood water level (F.W.L) : EL. 1,405.8m
- High water level (H.W.L) : EL. 1,405.0m
- Low water level (L.W.L) : EL. 1,391.0m
- Total storage capacity : 34.92 M㎥
- Effective storage capacity : 30.02 M㎥
- Dam Type : Earthfill Dam
- Dam Length : 1,052m
- Dam Height : 30.5m

![Project Location](image_url)
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1.1.3 Climate Conditions

Located near the equator and on the plateaus, the average temperature of Rwanda is as cool as 16 to 26°C around the year. From January to February, and from June to September, it belongs to the dry season, and between March and May and between October and December fall under the wet season. The mean yearly rainfall of the country is some 1,200 mm. <Figure 1.1-2> shows the status of its mean monthly rainfall and temperature for the period 1900 to 2009:

![Figure 1.1-2 Mean Monthly Rainfall & Temperature (Rwanda, 1900~2009)](image)

[Source] Climatic Research Unit (CRU) of University of East Anglia (UEA)

However, there is a substantial difference among different regions, which is why the country can largely be subdivided into the following 4 zones in terms of precipitation and climatological distribution:

- Western lowland: The western lowland refers to all areas adjacent to Lake Kivu, including the Imbo Plain and the Rusizi gorges. This lowland is among relatively steep-sloped regions starting from the Congo-Nile plateau. The altitude ranges from 900 to 1,800m, with 20 to 24°C in temperature and 700 to 1,400 mm in rainfall.

- High altitude region: The Congo-Nile plateau spreads until it meets the volcanic region to the north and the border to the south. The altitude ranges from 1,800 to 4,507m, with 16 to 17°C in temperature and 1,300 to 2,000mm in rainfall.

- Central plateau: The altitude of the central plateau ranges from 900 to 1,200m, with 18 to 21°C in temperature and 1,200 to 1,400 mm in rainfall.

- Eastern plateau: The altitude of the eastern plateau ranges from 1,100 to 1,200m, with 20 to 24°C in temperature and 700 to 1,400mm in rainfall. The rainfall of Nyagatare District in the eastern plateau amounts to 900 mm at its extremity, and some 1,400mm in the west:
1.1.4 Topography

The project area is located in Nyagatare District in Gatunda, Rukomo, Tabagwe and Karama Sectors. The dam area is lying between Karama and Gatunda Sectors respectively; in Bushara and Nyamirembe Cells.

The coordinate system used for conducting topographic survey is ITRF Rwanda (2005)

Because there is no an established permanent Bench Mark (BM) in the project area, a suitable Temporary Bench Marks (20 cm x 20 cm x 50 cm) was established while doing topography of this site in the feasibility study phase. And, the same temporal bench marks have been used in detail design phase.

1.1.5 Subsoil Conditions

The geology of Nyagatare is mainly consists of paleo to middle proterozoic the augen gneiss aged 1383±17Ma, and some intrusives such as pegmatite and quartz vein (986±10Ma), felsite (986±10Ma) and andesitic porphyry (undetermined, age unknown) are intruded along to the fissure and fractures of augen gneiss. The valleys having the stream flows are covered by young alluvial deposits of Holocene age.

Augen gneiss originated from granite is covered all of project area. The augen gneiss is a foliated, migmatic orthogneiss with microcline megacrysts (up to 2×5cm) which may constitute about one-third of rock. Individual augen may be composite or single microcline grains. The gneiss has an early migmatic development displaying a layered or vein structures. During the F2 deformation, the gneiss suffered retrogressive metamorphism under low amphibolite facies and greenshist-amphibolite facies. Augen gneiss in project area is shown well developed foliation but it forms massive rock mass and has rare or widely spaced joint. Intrusion Era of G3 granite which is the origin of augen gneiss is reported 1383 ±17Ma by Stijin DEWALE et al, 2010.

Augen gneiss (sound bd rock), which form the subsurface, are suitable for the dam construction. The bed rock is competent and joint spacing is generally between 1 m and 5 m.

Above the bedrock alluvial deposits (quaternary) of approximately 4.3 m to 16.0 m layer thickness are deposited.

The foundation soils under the dam embankment are summarized as follows:

- At the right dam abutment: dense and firm soil; overburden thickness is in a range of 0.5 m to 2 m on weathered granite rock and at the spillway location about 2 m; overburden is favourable in regard of reducing percolation ways under the foundation; cohesiveness will prevent horizontal displacements in subsoil; permeability is assumed to k = 10⁻⁷ m/s to 5·10⁻⁷ m/s. Rock can be expected
1. General Specification

approx. 25.6~36.0 m below NGL.

- At the left dam abutment: dense and firm soil; overburden thickness is in a range of maximum 3 m on weathered soil. permeability is assumed in a range of \( k = 1.17 \times 4.28 \times 10^{-7} \) m/s. Rock can be expected approx. 5.5~10.5 m below NGL.

- Riverbed is separated two parts; left side of Muvumba River forms riverbed terrace, right side forms plain riverbed lower about 10m in elevation than left side. Geological sequence from surface to bottom at riverbed is top soil, alluvial deposits, weathered zone and bedrock. Top soil at left riverbed terrace distributes up to 1.0m in depth from surface, clay and sandy clay good for core material distribute 6.0~10.5m, Sandy gravel good for filter material and concrete exist 11.0~16.0m in depth from surface. Beneath the alluvial deposits, weathered zone down to 28~32m in depth from surface and highly weathered augen gneiss with 0-80% in RQD is distributed beneath weathered zone.

- Top soil at right riverbed plain distribute up to 1.0~1.5m in depth from surface, clay distribute 6.0~10.5m in depth, clayey gravel with very low permeability exist 1.0~6.0m in depth from surface.

- Beneath the alluvial deposits, weathered zone distribute more than 40m in depth in BH-7 because of fault affection. To the right increasingly the depth of rock is more shallow, bedrock in BH-3 and 10 appear 8.3~8.5m in depth from surface. Bed rock is slightly to fresh augen gneiss with 30~100% in RQD.

- The results of the field permeability tests on the BH-7 within fault zone indicate that the permeability of fault zone is 2.83×10-5cm/s, which suggests that the fault beneath dam foundation have good watertightness. Because the proposed dam foundation laid on weathered zone and developed fault zone, curtain grouting was planned 20m in depth and consolidation grouting planed 10m to prevent fault affection, internal erosion by leakage and excessive settlement of core material.

No groundwater aquifer has been assessed, besides the area of the stream.

The average slope inclination is approximately 10 % to 20 % on the left and the right abutment side. Traces of landslide or other movement of the ground were not observed in the area of the dam abutments.

The spillway area is characterized by shallow overburden (approx. 1~2 m depth) on weathered granite. At the end of the spillway chute, there are 8m depth alluvial deposits consist of gray clay and gravelly clay. All alluviums will be excavated and foundation will be laid on bedrock.
Detailed Design for Muvumba Multipurpose Dam

Seismicity

Considering a seismic hazard map of East Africa an estimated seismic acceleration of not more than 0.1g can safely be used in the design of the dam structures.

According to the geological map the dam site is located on a fault line. The fault line’s trend follows roughly NE-SW as shown on the geological map’s excerpt below. No indications of an active fault or any evident geological feature was observed during the geotechnical investigation.

For more detailed information on the geological and geotechnical conditions at site it is referred to the Detailed Design Report, Section 3.2 “Geological and Geotechnical Investigation” (February 2016) prepared by KECC.

1.1.6 Present State of the Project Area / Actual Land Use

The land use / land cover data used herein include land cover maps covering Rwanda and Uganda provided by the RNRA and the Food & Agriculture Organization (FAO) geonetwork, respectively.

There are six types of land covers: Crops, Forest Plantations, Shrub Plantations, Shrubs, Savannah, and Urban Areas at Muvumba Dam Watershed

<table>
<thead>
<tr>
<th>Item</th>
<th>Area (km²)</th>
<th>Item</th>
<th>Area (km²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban area</td>
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<td>Shrub plantations</td>
<td>436.1</td>
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<tr>
<td>Crops</td>
<td>350.1</td>
<td>Shrubs</td>
<td>98</td>
</tr>
<tr>
<td>Forest plantations</td>
<td>1.9</td>
<td>Savannah</td>
<td>60.7</td>
</tr>
</tbody>
</table>

Table 1.1-1 Area of Land Use
1. General Specification

1.2 General Requirements

1.2.1 Standards and Regulations

All plant, materials and workmanship shall comply with international standards (ISO, EN, DIN, BS) or appropriate national standards where no other standard is given, for both manufacturing and testing. Where no comment is made against an item the Contractor shall assume that these standards are to be complied with.

Where specific Standards are referred to in the Specification, the Standard referred to shall be the most recent issue or revision of that Standard. Where the Standard has been withdrawn the reference shall be taken to refer to the Standard, which has replaced it.
The Contractor shall obtain for use on Site at least one copy (digital) of each applicable Standard. It is the Contractor’s responsibility to ensure availability of all standards referred to in the Contract, when requested by the Engineer.

All materials and workmanship not fully specified herein or covered by an approved standard shall be of such a kind as it is used in first class work and suitable to the local techniques.

1.2.2 Drawings, Method Statements and Other Documents

Standard Size of Drawings and Documents:

Drawings, whether to be supplied by the Engineer or the Contractor shall only be prepared according to standard sizes DIN A4 (210 x 297 mm) to DIN A0 (841 x 1189 mm), preferably DIN A3 or DIN A4.

Documents, whether to be supplied by the Engineer or the Contractor shall be prepared on standard size DIN A4 (210 x 297 mm), except where particularly agreed otherwise with the Engineer.

Drawings:

Wherever the term "Drawing" is used in the Specifications, it shall mean the Tender Drawings and/or the Working Drawings prepared by the Contractor and approved by the Engineer.

Tender Drawings:

Tender Drawings are the drawings prepared by the Engineer and are compiled in Volumes V of the Contract (Tender) Documents. The Tender Drawings show the Work to be done under the Contract, subject to Contractor's detailed design, Conditions of Contract, and to the provisions for variations of the Conditions of Contract. In general, the Tender Drawings are intended to indicate the scope and complexity of the Works and to illustrate all construction details, enabling the Contractor to prepare Working Drawings and if required detailed rebar drawings, bending schedules, etc.

Working Drawings:

Working Drawings are the drawings to be prepared by the Contractor. They shall show sufficient dimensions, specific and typical details to define the various features of the Works, thus enabling the Engineer to check and approve the design and the Contractor to perform the relevant works.

Working Drawings shall be submitted an adequate time prior to the planned start of respective construction works.
1. General Specification

Method Statements:
Method Statements are written by the Contractor in order to provide details on his proposed construction method for each category of the Works.

Method Statements shall be submitted an adequate time (i.e. at least 2 weeks unless agreed differently with the Engineer) prior to the planned start of respective construction works.

Documents to be supplied by the Engineer:
The Tender Drawings are prepared in consideration of maximum traffic and static loadings likely to act on the Permanent Works but not for temporary loadings resulting from construction stages.

The Engineer will issue no drawings other than those forming part of the Contract Document.

Checking of Engineer’s documents by the Contractor:
The Contractor is obligated to check thoroughly the Tender Drawings on the basis of the results of Contractor’s surveying work, with regard to the correctness of all dimensions and to inform the Engineer of corrections considered necessary by him.

Before designing, manufacturing, supply or execution of any part of the Works, the Contractor is to examine and verify the drawings of the Engineer with regard to the technical feasibility of construction, to the correctness of dimensions, as well as all other aspects which are of significance to the execution and completion of the Works.

The Contractor shall call the attention of the Engineer to any circumstances which should involve a change in the design in his opinion.

The costs resulting from discrepancies remaining in dimensions and other data on the drawings so examined by the Contractor, insofar as they have a negative effect on the execution and completion of the Works, shall be solely at the expense of the Contractor and shall not entitle him to any extra claim.

Documents to be supplied by the Contractor:
The Contractor is responsible for the preparation and adequacy of the Working Drawings of Permanent Works (e.g. electrical and mechanical works, dam instrumentation) and Temporary Works (e.g. formwork drawings, river diversion) including all calculations and documents, in accordance with the Contract.

The Contractor shall submit to the Engineer each drawing, calculation, method statement, and other document as draft version (2 print-outs and digital). After incorporating all corrections and alterations made by the Engineer and on receipt of the Engineer’s written approval of the draft version, the Contractor shall submit the final version (3 print-outs and digital) to the Engineer for distribution.
The drawings, method statements and documents to be provided by the Contractor shall include, but are not limited to:

- Method Statements for each category of the Works, such as dewatering / draining measures, excavation works (incl. excavation supports, etc.), filling works (defining construction materials, layer thickness, construction / compaction machines, number of roller passes, etc.), pipe laying works (incl. backfilling, compaction method above pipes), exploitation works of borrow areas, etc.
- Setting-out drawings (layout plans) and lists of coordinates of all benchmarks / stakes
- Survey drawings (longitudinal and cross-sections showing both finished lines and design lines)
- Drawings as required for the measurement and payment of the Works, including survey information (record, calculations, etc.)
- Drawings and calculations for all Temporary Works and construction stages planned by the Contractor, including any part of the Permanent Works, which is fully or partially used as Temporary Works or as a support thereof
- Drawings for all earthworks, including but not limited to:
  - Plans of earthmoving
  - Plans and cross-sections of open cut excavations showing side slopes, etc.
  - Dewatering plans including drawings, number of pumps, pump duties and disposal areas
  - Analysis, justification and proposals for improvement of subsoil bearing capacity (if required)
- Drawings for all civil engineering works, including but not limited to:
  - Drawings of formwork layout, reinforcement schedules and bending schedules
  - Detailed calculations, justifying stability and dimensions of structures, and its foundations, in full consideration of subsoil conditions and design criteria
  - Detailed drawings for all electrical and mechanical works, including drawings of assembly details and parts of assemblies / equipment, schematic flow diagrams, circuit diagrams, etc.
  - Drawings and manufacturing instructions for all materials and equipment, taking into account the materials and customary practices of the manufacturing firm
- Drawings, records and reports on specific construction measures to be supplied by
the Contractor in accordance with the provisions of the Contract

- As-built drawings for all Permanent Works, incorporating all changes or amendments made in the course of the construction works. As-built drawings shall be supplied to the Engineer immediately after completion of the respective works.

- Instructions (in form of lists, manuals, etc.), which are required by the Employer for proper operation, maintenance and repairs for all parts of the Works

- Detailed plans for Defect Liability Period including lists of defects, schedule for repair works

As soon as practicable after award of the Contract, the Contractor shall propose to the Engineer a complete list of drawings, calculations, method statements, and other documents to be submitted to the Engineer. The Engineer will determine those documents to be submitted by the Contractor for approval and those to be transmitted for information only.

However, the Engineer reserves the right to request any additional drawing or calculation at a later stage in order to facilitate proper checking of documents related to the Permanent Works and/or understanding of equipment functions and Temporary Works.

If not specified differently in the General or Particular Technical Specification, the Contractor shall submit all relevant drawings and method statements as soon as possible but at least three weeks before commencing with the respective Works.

Checking of Contractor’s documents by the Engineer:

All drawings, method statements and supporting calculations prepared by the Contractor for the Permanent Works are to be submitted to the Engineer for checking and approval.

All drawings, method statements and supporting calculations prepared by the Contractor for Temporary Works and construction stages are to be submitted to the Engineer for his information and comments.

The formal approval or the comments of the Engineer do not release the Contractor from his sole responsibility and liability for the proper design and execution and completion of the Works or from the remedy of any defects therein, in accordance with the Conditions of Contract.

Design calculations shall be sent with the drawings. No working or equipment drawing shall be approved until the Engineer is provided with the design calculations.

The execution of the Works and manufacture of materials according to the Working Drawings shall not start until either a copy of the respective drawing, approved by the Engineer as evidenced by his signature, is available or the approval is conveyed in writing.
1.2.3 Site Management Plans (Construction Site Setup, Site Safety, Traffic Control, Flood and Environmental Management, Quality Assurance)

The Contractor shall consider all manuals, plans, etc. prepared by the Engineer (e.g. Quality Control and Construction Supervision Manual, O&M manual, Emergency Preparedness Plan). Based on these documents the Contractor shall prepare its own plans to be used for site management, such as Construction Site Setup Plan, Site Safety Plan comprising also a Traffic Control Plan, Flood Management Plan and EMP, as well as a Quality Assurance Plan.

The Contractor shall submit to the Engineer each plan as draft version (2 print-outs and digital). After incorporating all corrections and alterations made by the Engineer and on receipt of the Engineer’s written approval of the draft version, the Contractor shall submit the final version (4 print-outs and digital) to the Engineer for distribution.

Requirements and contents for each plan are specified in the following:

**Construction Site Setup Plan:**

The Construction Site Setup Plan (in form of detailed layout drawings) shall be submitted by the Contractor within 28 days after receipt of the Letter of Acceptance.

The plan shall show all details relevant for site setup, such as:

- access road(s)
- site offices for the Contractor, the Engineer and the Employer
- area for labour camps and staff quarters
- sanitary facilities
- site laboratory
- workshops, stores, material sheds, etc.
- fixed installations for concreting, such as silo, concrete batching, mixing plant
- fixed installations of material treatment, such as controlling of water content (exposure to the air, scarifying and ploughing, etc.), crushing, sifting, washing, storage
- storage places for material, equipment, instruments, plants, etc.
- sign board
- site fence indicating the boundary of the construction work site
1. General Specification

**Traffic Control Plan:**

A Traffic Control Plan (in form of layout drawings) shall be submitted by the Contractor at least 2 weeks before commencing the earthworks.

The plan shall include but not limited to the following information:

- access road(s) to the Site and temporary construction roads on the Site
- turning area(s)
- area for parking spaces
- sign-posting

**Site Safety Plan:**

A Site Safety Plan shall be submitted by the Contractor within 28 days after receipt of the Letter of Acceptance.

The plan shall be in accordance with Section 1.3.9 and shall comprise at least the following information:

- workers health and safety (list of provided safety equipment, etc.)
- first aid on Site (first aid equipment / facilities, first aid kits with number and location, designated first-aiders and corresponding certificates of first aid course / refreshers course)
- fire emergency plan, including fire prevention, number and location of fire extinguishers
- proposed timing, interval and agenda of instructions in accident prevention and regular safety briefings for the Contractor’s staff, as well as regular safety liaison meetings between the Contractor and the Engineer
- reporting procedure in case of accidents, including names and mobile numbers of all persons to be informed
- telephone list, including names and mobile numbers of first-aiders, the Contractor’s Safety Coordinator, medical doctors, hospitals, ambulances, and civil defense, etc.
- detailed information (e.g. in form of drawings) on safety measures on Site, such as excavation supports, blasting measures, etc.
- safety requirements for blasting works, and for the use, storage and handling of explosives
Environment Management Plan (EMP):

The Environment Management Plan shall be submitted by the Contractor within 28 days after receipt of the Letter of Acceptance.

The plan shall be in accordance with the EIA (environmental impact assessment) prepared on behalf of the Employer, and Section 1.3.10, as well as all relevant national environmental and water regulations and laws. The EMP shall comprise at least the following:

- implementation of all requirements of the EIA
- monitoring programme to be followed during the construction phase for unavoidable impacts
- measurements to control / avoid pollution of the environment, including dust control on the Site and access roads to the Site, disposal location for waste arising from the Works, etc.
- measurements to control / avoid pollution of groundwater or surface watercourses, including discharge location for wastewater arising from the Works, storage areas for fuel, lubricants or other harmful materials, etc.

Flood Management Plan:

The Flood Management Plan shall be submitted by the Contractor within 28 days after receipt of the Letter of Acceptance.

The plan shall comply with the Temporary Works of the river diversion and cofferdam, including all relevant construction levels and shall be in accordance with the Emergency Action Plan (EAP) prepared on behalf of the Employer. The Flood Management Plan shall comprise at least:

- preparedness activities, such as observation of weather conditions / weather forecast, water level measurement
- identifying possible risks for the different construction levels
- defining mitigation measures to minimize damages at the construction site (e.g. timely removing of machines, equipment, materials from endangered areas), to minimize environmental impact and any safety risk for the Contractor’s staff and the local population
- nomination of persons responsible (even outside of working hours)
- provide the availability of the Contractor’s staff / workmen, machines, equipment,
materials in case of emergency even outside of working hours

Quality Assurance Plan:

The Quality Assurance Plan (e.g. in form of excel sheets) shall be submitted by the Contractor within 28 days after receipt of the Letter of Acceptance.

The plan shall be in accordance with the requirements of the General and Particular Technical Specifications (material specifications, testing programmes, compaction requirements, etc.). The Quality Assurance Plan shall be prepared for all relevant Works, such as earthworks, concrete works, pipe works, survey works, etc.

1.2.4 Construction Schedule

Construction schedules are required for proper planning, execution and monitoring of the Work.

Submittals:

A Construction Schedule shall be prepared and submitted within 28 calendar days after commencement date.

The schedule shall be updated monthly to accurately depict the actual progress he has achieved. The progress shall be overlaid on the schedule.

Additionally, the Contractor shall submit weekly Activity Schedules showing the locations of all operations and activities intended to be carried out during the following week.

Construction Schedule:

The Construction Schedule shall be developed in Gantt format or Precedence Diagram Method (PDM) using computerized project planning software (e.g. MS Project). The official commencement date shall be used as day number zero. The Engineer will have 15 calendar days after receipt of the submittal to respond. Upon receipt of comments by the Engineer the Contractor shall confer with the Engineer on the appraisal and evaluation of the proposed schedule. Necessary changes resulting from this review shall be made by the Contractor, and the schedule submittal shall be resubmitted for acceptance within seven calendar days. Upon acceptance, the schedule shall become the Contract Schedule and shall be the baseline from which changes in duration’s and logic will be determined.

The Contract Schedule shall include the following:

Activity descriptions shall briefly convey the scope of work indicated. Activities shall be discrete items of work that must be accomplished under the Contract and that when
complete, produce definable, recognisable entities or stages within the project and relate to the BoQ items.

Activities shall include critical Contract deliverables, such as but not limited to, the submittal and approval of permit applications and variances, samples of materials, Working Drawings, inspection and testing plans, safety and security plans and worksite control plans. In addition, activities shall be included for the procurement of critical materials and equipment, fabrication of special materials and equipment and their installation and testing.

The Contract Schedule shall be time-scaled and grouped by work areas and sorted by early start dates. The Contract Schedule shall be clear, neat and legible, and shall be submitted on minimum A3 size sheets. Each sheet shall contain a title block and a revision block.

The critical path activities shall be identified. Scheduled start or completion dates imposed on the schedule by the Contractor shall be consistent with the Contract dates and other restrictions.

Failure to include any element of work required for performance of this Contract shall not excuse the Contractor from completing the work by the completion date notwithstanding the acceptance of the Contract Schedule submittal.

**Progress Payments:**

The accepted Contract Schedule unless subsequently changed with the approval or at the direction of the Engineer, is the schedule to be used by the Contractor for the basis of progress payments planning, scheduling, managing and executing the work to be accomplished.

Except other acceptance of the Employer, the approved Contract Schedule in this period will be a basic to calculate the final escalation value for whole Contract. Escalation value of each IPC is only temporary payment.

**Updates of the Construction Schedule:**

Proposed revision to the accepted Contract Schedule shall be submitted to the Engineer on a separate fragment for review and approval prior to incorporation into the current Contract Schedule. This fragment must clearly outline the impact of the revision within the context of the Contract Schedule.

**1.2.5 Construction records and progress reports**

**Daily construction records (site diary):**

Construction records (site diary) shall be prepared daily by the Contractor. The records (original) shall be kept on Site to be viewed by the Engineer / Employer at any time. If
agreed with the Engineer, the Contractor shall submit a copy of the daily records to the Engineer at the end of each day.

The reports shall contain at least the following information:

- date, weather conditions
- manpower and equipment on Site
- works in progress, works completed
- orders from the Engineer
- material deliveries, tests conducted, results of inspections and tests, nature of defects found, causes for rejection, proposed remedial action and corrective actions taken, etc.
- signature of the Contractor's representative

**Monthly progress reports:**

Progress reports shall be submitted by the Contractor latest by the end of the first week of the following month. Each report shall be submitted as draft version (2 print-outs and digital). After incorporating all corrections and alterations made by the Engineer and on receipt of the Engineer's written approval of the draft version, the Contractor shall submit the final version (3 print-outs and digital) to the Engineer for distribution.

The reports shall contain at least the following information:

- identification, activity description, estimated total duration, estimated remaining duration, computer or specified early start date, computer early finish date, computer late start date, computer or specified late finish date and total float
- colored photographs for record purposes taken of the construction

**1.2.6 Photo documentation**

During construction of the Works, the Contractor shall provide the Engineer with color progress photographs which shall be taken as agreed with the Engineer at monthly intervals before, during and after construction, viewed from the same positions.

The Contractor shall provide the Engineer (within 10 days of the photographs having been taken) with the aforementioned photographs both in printed (color prints 12 cm x 9 cm in size) and electronic form (CD, DVD, or other).
On the reverse of each print the following information shall be shown:

- date photograph was taken
- description
- digital file number

Each set of photographs - after approval by the Engineer - shall be mounted in albums provided by the Contractor.

Electronic files and prints shall not be subjected to any alteration process.

The copyright of all photographs shall belong to the Employer.

1.2.7 Operation and Maintenance Manual

The Contractor shall prepare Operation and Maintenance Manuals (O&M manuals) for any equipment installed in the Permanent Works. To this end the standard manuals of the respective manufacturers shall be used as a basis. For preparation of such manuals, the Contractor shall consider the O&M manual prepared by the Engineer.

The Contractor shall submit to the Engineer each O&M manual as draft version (2 print-outs and digital). After incorporating all corrections and alterations made by the Engineer and on receipt of the Engineer's written approval of the draft version, the Contractor shall submit the final version (4 print-outs and digital) to the Engineer for distribution.

Basically, the manuals shall comprise the following:

- technical data on the equipment produced providing the required basic information
- drawings, diagrams, images or photographs to facilitate understanding and improve clarity
- precautions and warnings concerning the safety of personnel and protection of the equipment

The manuals shall be arranged in the following sections:

Part I – Operation:

- detailed description of the item / equipment and its function, incl. characteristic data (e.g. installed capacity or power rating, voltage, current, pressure, temperature, revolutions per minute, discharge, etc.)
- instructions for starting up (structured in initial starting up, normal starting up, starting up after maintenance), incl. precautions to be taken, critical points to be
1. General Specification

- operation instructions, incl. precautions to be taken, critical points to be observed, recommendation on establishing an operating log-book, and a table indicating possible operating difficulties with possible causes and remedial actions

- instructions for shut-down (structured in 'normal shut-down' and 'emergency shut-down'), incl. operations to be performed to stop operating the equipment, precautions to be taken and critical points to be observed

Part II – Maintenance:

- dismantling instructions, incl. procedures to be followed for dismantling and re-assembly, indication of special tools (where necessary), exceptional care or precautions to be taken

- maintenance instructions, incl. preventive maintenance (e.g. lubrication, etc.), a program indicating maintenance / checking intervals, indication of special tools (where necessary)

- information on adjustments and clearances of instruments, alarm, shut-down signals, operating conditions (temperature, pressure, discharge, etc.), structures in 'recommended range (min / max)' and 'effective (ideal)'

Part III - Dismantling, spare parts lists:

- instructions for ordering spare parts (e.g. name, reference number, serial number, etc.), list of

- recommended spare parts, list of manufacturers' spare parts (incl. part identification, current

- delivery price), and respective drawings / specifications

- specifications on performance, and special arrangements for storing and handling certain parts
1.2.8 Site meetings

A pre-construction meeting will be held after award of Contract, but prior to starting work at the Site. Participants will be the Employer, the Engineer, the Contractor, the Contractor’s Safety Coordinator, and possibly other invited parties, such as representatives of governmental or other regulatory agencies, etc.

The minimum agenda shall be:

- General introduction of key personnel and responsibilities
- Confirm Contractor’s submission of all insurances, performance bond, etc.
- Confirm completion of permits and site acquisition
- Confirm construction start date and contract period
- Submission of the Construction Schedule by the Contractor
- Procedure for submittal of Working Drawings and samples
- Procedure for processing of field decisions and change orders
- Procedure for maintaining record documents
- Procedure for survey and existing field elevation
- Procedure for communication
- Procedure for processing Contractor’s payment request
- Confirm hours of operation
- Establishing long lead items and ordering procedure
- Safety / first aid procedure

Besides ad hoc meetings, informal meetings, etc. regular site meetings shall be held. Site meetings shall be attended by approved representatives of the Contractor, the Engineer, the Employer, and other invited parties (if required).

Site meetings will be held at intervals and places established during the pre-construction meeting (e.g. weekly at the Engineer’s meeting room).

Prior to each site meeting, the Contractor shall submit to the Engineer a brief report on his working progress (maximum 2 pages), including an Activity Schedules showing the locations of all operations and activities intended to be carried out during the following week.
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1.2.9 Complementary geotechnical data

A geotechnical investigation has been carried out at the dam site and at potential borrow areas.

The Contractor shall draw his own conclusions from the data, particularly in regard to the rock level, potential borrow areas, etc. If the Contractor wishes, he may make further explorations at his own expense and in agreement with the Engineer.

The geotechnical complementary data retrieval may include the following:

- Study of the foundations of the important works, such as dam embankment including appurtenant structures.
- Study of the borrow areas for each type of material.
- Studies of mineral construction materials in the vicinity of the embankment, including a study of identification for each haul and a complete test of behavior per family of ground encountered.

1.2.10 Construction materials and permanent equipment

All materials and equipment for Temporary and Permanent Works, shall be of the best quality, new, unused, and of the most recent design of their respective kinds, as described in the Specifications.

Insofar as certain construction materials or equipment for the Temporary and Permanent Works are not mentioned or no additional special tests are specified, the materials and equipment must at least meet the respective requirements of the standards approved by the Engineer.

When any material, article or item of equipment is to comply with a particular standard, the product or its original container shall bear the stamp of the registered certification trade mark of the relevant standard.

Alternatively, the Contractor shall submit test certificates, furnished by the manufacturer, indicating compliance with the standard.

For all supply items, such as permanent installations, equipment, etc., but also for specially imported materials, the Contractor shall submit the technical literature from different suppliers / manufacturers for the Engineer’s selection.

Manufacturers / suppliers:

Before ordering, the Contractor shall submit to the Engineer all the appropriate documentation, such as manufacturer’s / supplier’s brochure, list of material / equipment and
personnel, certificates of calibration as well as the guarantees offered.

Any manufacturer and supplier is subject to the Engineer's approval.

Material samples:

Where specified or otherwise required by the Engineer, material samples shall be provided by the Contractor prior to placing the orders, free of charge. Such samples shall facilitate the approval of material and quality control of supplies throughout the Works.

Supply orders:

The Contractor shall submit to the Engineer well in advance draft copies of orders or subcontracts which he intends to place with any supplier or manufacturer for any equipment and materials required for the Permanent Works.

Examination and tests:

Materials, articles or equipment shall be made available or delivered to the Site a sufficient period before they are required for the Works, enabling the Engineer to take such samples as he may consider suitable for examination and testing.

Unless otherwise designated, the costs of all tests required in accordance with the standards or the Specifications shall be deemed to be included in the rates of the Bills of Quantities.

Protection:

All materials or other items intended to form a part of the Works, whether during transport or stored at Site, shall be adequately protected against contamination, deterioration, damage and the like, at all stages, and arising from any reason.

Such items which, in the opinion of the Engineer, became unfit for use in the Works, must be removed from the Site and replaced at the expense of the Contractor.

Rejection of materials:

Any materials, articles or equipment not in accordance with the standards and Specifications may be rejected by the Engineer. Any materials, articles or equipment rejected by the Engineer shall be removed immediately from the Site. Replacement shall be provided by the Contractor at his own expense.

A rejection by the Engineer shall not release the Contractor from his obligation to adhere to the approved time schedule.

Manufacturers' guarantee:

Wherever guarantees of operating capacity and efficiency, proper functioning, durability and the like are called for, or where it is specified that the manufacturer shall furnish necessary performance data, shall supervise the placing of the equipment, adjust it after installation as
necessary and maintain it for the required period and perform similar other duties and services, the Contractor shall be held responsible for performance of the specified services and for any default on the part of his suppliers / manufacturers.

1.2.11 Testing and Inspection

All materials and items intended to form or forming a part of the Works, all workmanship and all Work under the Contract shall be subject to the approval of the Engineer. From time to time it shall be subjected to such examinations and tests as provided for in the Standards and Specification and as the Engineer may direct at the place of manufacture or of fabrication or at the Site, or at any other place or at all or any of such places.

The Contractor shall provide all such attendance, assistance, facilities, instruments, machines, equipment, labour, materials, items and transport as required for examining, measuring, sampling and testing the Work as well as the quality, weight and quantity of materials and items intended to form or forming a part of the Works, as and when selected and required by the Engineer. The Contractor shall reinstate such work, materials and items if necessary in the opinion of the Engineer.

The costs for samples, sampling, testing and inspection intended and provided for in the Standards and Specifications will not be compensated separately and are deemed to be covered by surcharges and overheads to be included in the rates of the Bill of Quantities.

Samples:

Samples shall be taken in accordance with the relevant Standards, and in such a way and in sufficient number to be considered as representative for the full quantity of materials and items from which they are taken or for the workmanship to be tested.

Samples submitted for approval of materials and items to be supplied or of workmanship and which are subsequently approved, will be kept by the Engineer.

Tests:

All materials and items intended to form a part of the Works shall be tested in accordance with the Standards and Specifications before leaving the manufacturer's or supplier's premises. The Contractor shall furnish the Engineer with the test certificates of each consignment from the manufacturer or supplier, as the case may be.

Engineer's Inspection:

Whenever considered desirable by the Engineer, inspectors shall be sent to the manufacturer's or supplier's premises to test or to witness the tests of the materials and items or to inspect the manufacture.
The Engineer and his inspectors shall have free access to all such places of testing, and the Contractor shall impose these conditions on all his sub-contractors and suppliers.

**Engineer's right to reject:**

Neither the production of a manufacturer's test certificate, nor the omission of the Engineer to send an inspector, nor the presence of the Engineer during testing or manufacture at the manufacturer's or supplier's premises, shall prejudice the right of the Engineer to reject after delivery to the Site, materials and items intended to form a part of the Works, which are found unsuitable or not to be in accordance with the Standards and Specification.

### 1.2.12 Workmanship, notice of operation

Workmanship shall be of the best quality appropriate to each category of work and shall be in accordance with the standards, Technical Specifications and the present state of art.

**Information to the Engineer:**

All operations have to be carried out in close coordination with the Engineer, who is to be informed well in advance of the start of any new operation and of the day to day activities. No new operation or work in any new area shall be started until the Engineer's consent has been obtained.

Prior to the commencement of any particular work, the Contractor shall submit details of his proposed methods, schedule and sequence of operations to be followed (Method Statement).

**Contractor's Responsibility:**

Notwithstanding any testing and/or approval by the Engineer, the Contractor shall be fully responsible for the quality and functioning of the Permanent Works in accordance with the Contract. The Contractor shall implement his own quality control.

Authorization to repair or refinish shall not constitute a waiver of the Engineer's right to require replacement of any item or work, if and when after such repairing and/or refinishing the Work is unsatisfactory in the Engineer's opinion.
1.3 The Site

1.3.1 Site area and Installations

The term "Site" denotes any or all of the sites as well as working and storage areas to be established by the Contractor for the due performance of the Contract. The Contractor shall not use the Site for any purpose not required by the Contract.

The Employer will make available to the Contractor the areas to be used as a construction site, including storage and working areas, free of charge but on an as-seen basis.

The Contractor shall also specify all issues related to the supply of electricity and water, including drinking water to the site areas, as well as to the actual construction site. The quality of the water shall be approved and suitable for the purpose for which it is intended.

The Contractor is deemed to have investigated the possibilities and to have provided for the required means in respect of the regular power and water supply to the Site to the extent required for the Works.

The Contractor shall provide and maintain all site infrastructure and installations necessary for the satisfactory execution and completion of the Works throughout the period of the execution of the Works. This shall include but not be limited to the following:

- clearing from obstructions, grading and improvement of site area
- building, furnishing and outfitting of all required offices, workshops, stores, silos, material sheds and sanitary facilities
- building and furnishing / outfitting of all required labour camps and staff quarters, including sanitary facilities, storage for fuel, etc.
- provision of installations for power, lighting, water and any other supply and service lines
- fencing of the site area(s) and adequate protection of the Site against theft and accidents (e.g. fixing of all required safety and warning signs, etc.). The Contractor is fully responsible in this regard.
- transport, import and assembly ready for use of all required vehicles, construction plant, floating equipment, e.g. dredgers, excavators, barges, launches, cranes, trucks, batching plants, cooling equipment for aggregates and water, concrete pump systems, compactors, vibrators, cutting, welding and sandblasting equipment, pumps, generators, spare equipment, diving equipment, tools, etc.

The Contractor shall provide, maintain and clean sanitary facilities including suitable and sufficient toilets (mobile toilets or latrines), wash hand basins, wash-rooms with shower
facilities, etc. for the Contractor’s. Toilets and latrines shall be properly cleaned at all times.

Latrines shall be located in the site area far from river bed and the dam catchment. The Contractor shall ensure that his personnel do not foul the site but make proper use of the latrines.

The Contractor shall provide, maintain and clean suitable and sufficient labor camps / staff quarters at or near the Site. The camps shall be customary, in accordance with the local laws and regulations and to the satisfaction of the Engineer.

The Contractor shall make his own arrangements for yards, stores, workshops, offices etc. and for all services in connection therewith.

The Contractor shall construct on the Site appropriate storage places and infrastructures for placing all materials, equipment, instruments, plants, etc. at his own risk all. Storage places shall be located at a properly arranged location at a safe distance from the river and other water courses to prevent from water logging or sweeping away.

The whole Site shall be kept clean and tidy. All refuse shall be deposited in an area specially provided for this purpose and regularly be disposed off at official dumping sites / facilities. Wastewater shall be disposed of the Site to the satisfaction of the Engineer and so that there is no damage or complaint.

Before construction of any site installations, the Contractor shall submit his proposal of the Construction Site Setup Plan for the Engineer’s approval.

The Contractor shall give free access to his installations to the Engineer and the Employer, and to any other person approved by the Employer. The Engineer is authorized to check the site installations at any time, and if required, to demand extension, additions and repair or maintenance measures.

All installations shall be regarded as destined exclusively to the works which is the object of this invitation to tender. The Contractor shall not use them for any other work without the written agreement of the Employer or the Engineer.

Site infrastructure and installations shall be removed from the construction site by the Contractor at the completion of construction, when ordered by the Engineer. The Engineer may at any time give the Contractor notice in writing to demolish and remove those infrastructures which are no longer required. After demolition and removal the Contractor shall level, clear, restore and make good the sites and surrounding ground and fill in and compact all latrines, drains, pits and similar works leaving the whole area in a neat and tidy condition to the satisfaction of the Engineer.
1.3.2 Site Access

The Contractor shall assess his own need for access roads to the construction site, to storage areas, temporary offices, etc., as well as to borrow areas and quarries. The Contractor shall include all costs for improvement, strengthening or repair of such roads or bridges (considering the required load capacity) in his unit prices.

Above refers also to roads necessary for the transportation of materials, equipment, and machines to and from the Site.

All access roads, as well as all other site areas, which shall be often used by trucks, shall be paved with proper material. The Contractor must keep all roads and site areas free from dust by watering or sprinkling from a browser (water tank). Dirt roads shall be sprayed, whenever increased dust levels are inspected or as required by the Engineer. Costs are to include in the unit rates.

Transport on public roads:

The Contractor shall conform to local legislations and public traffic regulations, particularly with respect to permissible loads on the axles, dimensions restrictions, and other technical parameters. The Contractor shall comply with all reasonable restrictions which may from time to time be imposed by the Engineer, the Employer, Police, Responsible Authority or Owner.

The Engineer shall have the power to restrict the Contractor's use of any roads, either in direction of traffic, speed of traffic or numbers of vehicles in order to preserve such roads or to make such roads safe for use by the general public.

The Contractor shall maintain all access roads throughout the duration of the Contract so that they are open to traffic at all times. The Contractor is obliged for minimizing the interfering with public traffic. Damage to roads and tracks caused by the Contractor shall be repaired at the Contractor's expense. In particular the Contractor shall fill potholes in roads with road-stone when these are deepened by his vehicles.

The Contractor shall not run tracked vehicles or tracked plant on any public or private road without the written approval of the Engineer / Employer or the Responsible Authority or Owner and subject to such conditions as each may reasonably require.

The Contractor shall make a record to be agreed by the Engineer of the conditions of the surfaces of any private lands or of any public cultivated or maintained lands over) which access to the site lies before use for access. He shall keep such surfaces in a reasonable state of cleanliness and repair during the execution of the Works. On the termination of the Contractor's use of such access he shall restore the surfaces to a condition at least equal to that obtaining before his first entry on them.
Circulation on the construction site:

The Contractor shall make provisions to ensure, during the execution of the works, the maintenance of the pedestrian and traffic on the normal ways crossing the construction zones which make the object of this tender. All the site and roads are to be permanently watered (wetted) in order to avoid dust.

The Contractor shall execute temporary works and deviations necessary. He shall ensure the indications during the day and night as well as maintaining security guards imposed by the regulation in force.

Temporary bridge:

The Contractor shall construct a temporary bridge for public traffic during the construction period. The assumed traffic load is 20 tons.

In the case that the Contractor wants to use the bridge, he must maintain and repair the bridge without any payments. Further any additional requirements (e.g. heavy loads) are on the Contractor's expenses.

The Contractor shall submit Working Drawings to the Engineer's approval. The bridge is considered as "temporary works".

1.3.3 Sign Board

At the entry of the Site, the Contractor shall install a sign board. The sign board shall be installed within the first 10 days after opening of the construction site. Its exact location shall be determined after agreement between the Employer, the Engineer and other beneficiaries on the issue.

The metal sign board shall be fabricated and erected by the Contractor. The supports shall be in metal hollow sections with buttresses fixed on adequate foundation.

The minimum size of the sign board shall be 1.0 m × 1.5 m. The text (non-restrictive) shall be painted in black (type height 8 cm) on white background. All paint used shall be exterior painting.

Wording shall be as directed by the Engineer, but generally the board shall show the following:

- project name
- project data, such as dam height, reservoir volume, command area
- names and company logos of the Employer, the Engineer and the Contractor
- date of commencement, date of completion
1. General Specification

The sign board shall be maintained by the Contractor, in good condition, at all times, for the duration of construction.

The sign board shall be removed from the construction site by the Contractor at the completion of construction, when ordered by the Engineer.

No any other advertisement can be displayed on the Site without prior authorization by the Employer.

1.3.4 Boundaries of Works

The Employer will be responsible for making available the land upon which the Works are to be constructed.

The boundary of the land acquired for the construction of the Works will be indicated by the Engineer. The Contractor shall set out, provide, erect, maintain and reinstate, from commencement to final completion of the Works, a site fence indicating the boundary of the Site. The site fence shall have a minimum height of 1.8 m. The fence shall be made at least of metal posts with wire mesh, or as required by the Engineer.

The Contractor shall not exceed the limits of the Site as shown on the Drawings except in exceptional circumstances with prior approval of the Employer.

The Contractor shall be responsible for obtaining the consent of the owners, tenants or occupiers of private land to the use of such land for temporary access or for other temporary purposes outside the limits of the Site. Before entering upon such private land, for the purpose of commencing construction the Contractor shall confirm in writing to the Engineer that he has obtained this consent.

The Contractor shall at his own expense pay all costs, expenses, rentals, compensation or other disbursements which may be incurred by him in negotiations with the owners, tenants or occupiers and during the subsequent use by him of such private land or roads for these purposes.

1.3.5 Remedies of Works

The Contractor shall be responsible for all damage which he may inflict to land and property lying outside the limits of the Site as defined above. Compensation for damage to such land or property caused by the Contractor shall be assessed by the Appropriate Government Authorities for settlement by the Contractor through the Employer.

The Employer will be entitled to withhold from any payments due to the Contractor sufficient sums that may appear to him to be necessary to cover the Contractor's liabilities under this
clause until evidence is produced by the Contractor to the Engineer to show that the Contractor's liabilities in this respect have been finally settled and discharged.

1.3.6 Existing Services and Installations

The Contractor shall take every precaution to ensure that all existing services and installations, such as pipes, culverts, drainage and irrigation ditches, cables, boundary walls and fences, retaining walls, or any other structure disturbed, within and near the line of excavation, are located, supported and safeguarded from damage. Any damage caused to any such services and installations attributable to the Contractor's operations, his constructional traffic or his negligence shall be made good by the Contractor at his own expense to the satisfaction of the Engineer.

In case temporary removal or diversion of any existing service or installation becomes necessary for proper execution of the Work, the Contractor shall obtain permission from the Employer or responsible Authority. The Contractor shall carry out the work at his own expense in a manner and at times to be approved by the Employer or responsible Authority. He shall subsequently reinstate the Work to the satisfaction of the Employer or responsible Authority.

In the event of the Employer or responsible Authority electing to repair such damage and/or to arrange for temporary removal of an existing service, the Contractor shall pay the cost of his or their doing the work. Should the Contractor fail to pay within a reasonable period of the account being presented, the Employer reserves the right to settle the account and deduct the sum paid by him from monies due or which may become due to the Contractor.

If in the opinion of the Engineer, the Employer and/or responsible Authority it should become necessary to provide permanent support for any existing service or installation exposed or injured during or after the execution of the Works, the Contractor shall carry out promptly such additional works. Payment for such additional work will be made in accordance with the Conditions of Contract, provided always that the necessity for such permanent support has not arisen due to the fault of the Contractor.

The Contractor shall at his own expense provide temporary fencing and security measures at all times to protect any affected properties.

1.3.7 Keeping Works Free of Water

The Contractor shall make his own arrangements and bear all costs to protect the Works against severe deleterious effects from water of any source (river, rain, ground water, etc.) as required for construction, installations, inspections, or safety.
1. General Specification

The Contractor shall construct, operate and maintain all cofferdams, diversion canals, drainage ditches, culverts, drains, pipes, pumps, etc. and other temporary dissipation and protection structures as for the purpose under this subsection. As soon as these structures and facilities are no longer required, they shall be demolished so as not to impede commissioning of the Works.

The Contractor shall submit Method Statements and Working Drawings of all dewatering measures to the Engineer for his information and comments.

Notwithstanding any consent by the Engineer of the arrangements made, the Contractor will be held responsible for the sufficiency thereof and any consequences arising from damage to the Works and any loss of production or other costs.

1.3.8 Force Majeure, Bad Weather

Without prejudice to other stipulations in the Contract, all constraints related to the presence of risks caused by water (including rain, river and ground water), all additional work which may prove necessary on this account, all damage caused by water, all pumping and all structures not mentioned in the Contract which the Contractor considers necessary for water control, shall be at the risk and expense of the Contractor.

The Contractor shall be responsible for all damage caused to foundations, embankments or structures whether constructed by him or otherwise related to the Works, or any part of the Works (including installations on-site, materials) and occasioned by floods or runoff or by failure of any part of the diversion or protection works carried out by the Contractor. Any repairs that are necessary shall be carried out at his own expense.

The Contractor has to provide adequate measures to measure and document the flow on the dam site during the construction phase.

The Contractor shall insure his Works against damage by flooding and submit a copy of the insurance certificate to the Engineer. Force majeure is defined as a flood event exceeding 5 year probability (50.7m³/s). It is the Contractor who shall prove the case of force majeure by flooding.

The Contractor shall adapt the program of Works in order to minimize the risks and protect the Works against any damage which may result from:

- Flood
- wind / storm
- waves
**Force majeure:**

In the case of force majeure, for example exceptional floods, earthquake or outbreak of war, it is likely to release the Contractor from his responsibility. Here, the damage caused to the Works, the installations at Site and the materials shall not be attributable to the Contractor.

The Contractor shall undertake repairs. He will receive for that remuneration calculated by application of the price in the BoQ and possibly of the price of the Contract by “force account”, made deductions of the percentages for benefit, unforeseen and others. This remuneration shall be paid after deduction of the benefit and the percentage for risks and unforeseen.

The Contractor shall take all necessary information with regard to the hydrological trends of the rivers / streams, the water level reached by the exceptional risings and their period of occurrence.

In case of force majeure, the Contractor shall forward a technical repair program including a repair schedule considering how to minimize delays. Both will be subject to approval of the Engineer.

**Bad weather:**

In case of bad weather, for example heavy rains, the Contractor may give written notice to the Engineer of stopping the works temporarily. The Engineer can authorize stoppage of the works.

The suspension of work due to heavy rains shall refer to earthworks only. In this period, the Contractor can carry out concrete works (prefabricated and cast in place) located in dry place, etc.

Recommencement of the works shall also be by written notice to the Engineer.

### 1.3.9 Health and Safety During Construction

The Contractor shall comply with the requirements of the World Bank’s EHS Guidelines (World Bank Group Environmental, Health and Safety, Guidelines) and all relevant national health and safety regulations.

Use of standard space safety precautions shall include, but not be limited to, sound design and erection of Temporary Works, adequate illumination for night operations, instruction in accident prevention for all staff of the Contractor, personal safety equipment, traffic control and related sign posting, guards, walkways, scaffolds, ladders, bridges, gangways as well as fire fighting and other safety devices and equipment as may be necessary to prevent accidents.
1. General Specification

The Contractor shall appoint a full time Safety Coordinator whose role shall be to promote, monitor and enforce safe working practices on the Site. The Safety Coordinator shall be a senior member of the Contractor’s staff.

The Contractor shall arrange and undertake regular safety briefings for all of his staff / workmen, sub-Contractor’s staff, visitors, etc. In addition, he shall ensure that regular safety liaison meetings are held between the Contractor and the Engineer. The Contractor shall carry out a safety audit of the Site at intervals not exceeding one month.

The Contractor shall provide all personal safety equipment (including safety helmets, safety shoes / boots, protective gloves, etc.) for use on the Works. Where such equipment is subject to statutory inspections, the Engineer shall be provided with copies of the inspection reports.

The Contractor shall ensure that all statutory safety obligations are met in respect of anyone entering the Site.

Before commencing any construction works, the Contractor shall submit a Site Safety Plan for the Engineer’s approval.

**First aid:**

The Contractor shall provide and maintain adequate first aid equipment and facilities on the Site for the whole duration of the Contract.

First aid kits shall be kept at easily accessible places at the Site. The places shall be prominently marked.

A sufficient number of the Contractor’s staff shall be fully qualified in first aid, so that first aid is immediately available in case of accident at any time and at any place. The designated first-aiders shall be made known to all persons working on Site by posting of their names and mobile numbers at a prominent place on Site and at all site offices.

The first-aiders shall undertake the necessary first aid course respectively refreshers course. The certificates of these courses shall be submitted to the Engineer.

**Arrangements with medical doctors and hospitals:**

The Contractor shall make arrangements with a qualified medical doctor to be called to the Site when required for routine or emergency consultation. The transport shall be provided by the Contractor.

Arrangements shall be made by the Contractor with the nearest suitable hospital for the acceptance of urgent cases of sickness or injury.

Arrangements made regarding medical attendance shall be subject to the approval of the Contractor’s Safety Coordinator and the Engineer.
Accidents:

The Contractor shall promptly, but in any case within 24 hours, report any accident at or near the Site, or in connection with the execution of the Works to the Employer and the Engineer. The Contractor shall also report such accident to the competent Authority, whenever such report is required by law.

If death, serious injuries, or serious damages are caused, the accident shall be reported immediately by telephone or messenger to both, the Employer and the Engineer.

If any claim is made by anyone against the Contractor or a sub-contractor on account of any accidents, the Contractor shall promptly report the facts, in writing, to the Employer and the Engineer, giving full details of the claim.

A telephone list for summoning aid, such as first-aiders, doctors, ambulances, and civil defense from outside sources shall be conspicuously posted in a prominent place on Site and at all site offices.

Fire protection:

Contractor shall take all necessary precautions to prevent fires at or adjacent to the area of Work, buildings, access road, etc., and shall provide adequate facilities for extinguishing fires which do occur.

Any fire damage caused by the Contractor are in the responsibility of the Contractor. The Contractor shall submit a fire emergency plan to the Engineer’s approval.

Security of the working areas:

The Contractor shall be responsible for all measures necessary to secure the working areas, including but not limited to:

- temporary site fence indicating the boundary of the Site
- adequate excavation supports
- marking of all open excavations and other obstructions by approved signs, fences, barricades, and lights
- marking of areas where blasting (explosion) takes place by approved signs, fences, barricades, and lights and informing / warning of all persons on Site on blasting activities (time of blasting, location, safety distance, etc.)
1. General Specification

1.3.10 Environment Protection and Monitoring

The Contractor shall comply with the requirements of the EIA (environmental impact assessment) prepared on behalf of the Employer, and with all applicable Environmental and Water Laws and the relevant national regulations and laws.

Based on the above, the Contractor shall prepare and implement the EMP. All unavoidable impacts shall be monitored by the Contractor during the construction phase.

The Contractor shall be responsible for all matters whatsoever arising out of or in connection with the processing, removal, transport and disposal of matter, spoil, and other waste material.

Refuse, and rubbish, useless rubble of every kind shall be removed frequently and regularly (at least once per day) from the Site and disposed of by the Contractor at his own expense to an approved tip. The Contractor shall provide portable metal boxes for the collection of rubbish and garbage bins at the rest areas of the employees.

The Contractor shall take all reasonable measures to ensure his activities do not cause pollution of groundwater or surface watercourses by fuel, lubricants or other harmful materials. Storage areas of these materials shall be located away from the above water courses and adequately constructed (e.g. concrete surface, surrounded by an embankment) in order to retain the materials in case of accidental leakage.

Discharge location of water and wastewater arising from the Works, including water from cleansing, testing, etc., will be decided subsequent.

The Contractor shall give strict instructions to his staff to use the sanitary accommodation provided.

The Contractor shall be responsible for noise and dust control on the construction site.

1.3.11 Retransforming the Site

At completion of the Works, all the areas of the Site shall be returned in a neat and tidy condition to the satisfaction of the Employer. The retransforming works of the Site shall be performed by the Contractor according to the Technical Specifications and to the satisfaction of the Engineer.

This will include but not limited to:

- cleaning of all storage and disposal areas, not even unusable material shall remain there
- demolition and removal of site infrastructure and installations, including leveling, clearing, restoring and making good the Site and surrounding ground
• filling in and compaction all latrines, drains, pits and similar works

• restoring areas used as borrow areas (areas within the reservoir: profiling and leveling, areas outside the reservoir: flattening and spreading of topsoil, etc., this works may include both backfilling and excavation)

• restoring the surface of access roads to a condition at least equal to that obtaining before the Contractor’s first entry on them

1.4 Enginee\'rs Requirements

1.4.1 Provide the Engineer’s Site Office

The Contractor shall provide the Engineer’s site office fully equipped with furniture, equipment and instruments. The office shall be sited at a location central to the Works as approved by the Engineer.

Before construction of the site office, the Contractor shall submit his detailed proposal for the office (location, type / material, size, arrangement) to the Engineer for approval.

The offices, equipment and instruments shall be provided completely before any construction works commence.

The Contractor shall be responsible for providing and maintaining all temporary services including gas, electricity, potable water, etc. as required by the Engineer.

There shall be hard-standing areas for at least six vehicles with 4 shaded parking spaces.

The office shall be in a building constructed of approved materials. The office shall be weather proof, insect proof, properly ventilated, insulated, naturally and electrically lighted, painted and fitted with secure lockable doors and windows in each room.

Number and size of the office rooms shall be as follows and/or as defined by the Engineer:

- 1 room for Resident Engineer approx. 4 m × 4 m
- 1 room for Assistant Resident Engineer approx. 4 m × 3 m
- 1 room for Surveyor approx. 4 m × 3 m
- 1 room for Structural and/or Land Husbandry Expert approx. 4 m × 3 m
- 1 room for typist / filing approx. 4 m × 4 m
- 1 meeting room approx. 5 m × 4 m
- 1 store room approx. 4 m × 3 m
1. General Specification

• 1 kitchen approx. 3 m × 3 m
• 2 toilet rooms respectively mobile toilets, fully equipped with wash hand basin, toilet roll bar, etc.

Throughout the duration of the Contract, the Contractor shall maintain the office and equipment / instruments to the satisfaction of the Engineer. The office rooms, including kitchen and toilets, shall be cleaned every day and guarded at night.

Ownership of the office will revert to the Contractor at the conclusion of the Contract.

1.4.2 Provide the Engineer’s Office Equipment and Software

The Contractor shall provide office equipment and instruments for the Engineer’s site office. Prior to placing orders for any equipment / instrument the Contractor shall submit his detailed proposal for each item for the Engineer’s approval.

Unless otherwise instructed by the Engineer, the equipment shall include the following items:

• 6 desks (approx. 0.8 m × 1.8 m)
• 6 mobile pedestal with lockable drawers
• 6 desk chairs with arms
• 4 tables (approx. 1 m × 2 m)
• 8 chairs
• 4 two-door metal cupboards, lockable
• 7 shelves for folders, etc., size: in total covering one of the inner walls of each office / room
• 7 filing trays
• 1 flipchart with flipchart paper and markers
• 8 waste paper baskets
• 2 sets of keys for all desks, cupboards, doors, etc.
• 1 safe, floor mounted, electronically lockable with a number combination, alternatively with key (2 sets of keys)

Following additional equipment shall be provided by the Contractor:
Detailed Design for Muvumba Multipurpose Dam

- 1 photocopy machine, A4 and A3 size trays, auto-feed
- 2 computers with MS Office application and internet connections
- 2 printers (1 colour printer A3, 1 laser printer A4)
- 1 scanner (either separate, or included in the copy machine or printer)
- 2 mobile phones
- 2 mobile radio units, including 2 battery recharge facilities and three sets of spare batteries
- 1 digital camera
- 2 electric pocket calculators with memory and trigonometric functions
- 2 torches with 2 NICAD batteries and battery charger
- 1 compass / clinometer
- protective clothing, such as safety helmets, safety shoes, safety boots, protective gloves, etc. for the Engineer’s staff, the Employer, visitors, etc.
- 1 water level meter with at least 30 m tape suitable for determining depth of water in piezometers (standpipes)
- additional equipment, such as safety ropes, plumb bob and chalk line, geologist’s hammer, sledge hammers (one 7 lb sledge hammer, one 2 lb lump hammer) and claw hammer
- kitchen utensils, such as refrigerator, electric stove, electric kettle, cups and glasses, sink, store cupboard and work surfaces, etc.

Ownership of the equipment and instruments will revert to the Contractor at the conclusion of the Contract.

1.4.3 Provide Cars for the Engineer’s Supervisor

The Contractor shall purchase and supply two cars with four-wheel drive (maximum two years old) for the Engineer’s supervisors. The cars shall be available for the Engineer over the complete duration of the Contract.

Throughout the Contract duration, the Contractor shall provide allowance for the cars and car insurances as well as fuel (according to requirements of the Engineer). Further, the Contractor shall preserve and maintain the cars to the satisfaction of the Engineer. This shall include all necessary repair works and car spare parts including their installation.
1. General Specification

Ownership of the cars will revert to the Contractor at the conclusion of the Contract.

1.4.4 Miscellaneous Services for the Engineer

The Contractor shall make available all labour, equipment, materials, access, and any other thing as the Engineer may require to conveniently and quickly carry out any inspections the Engineer deems necessary at any time during the Contract. This may include survey works, sampling and testing or any other field work in connection with the Works.

The Contractor shall provide miscellaneous services for the Engineer at his own expense.

1.5 Site Laboratory

1.5.1 General

The Contractor shall in accordance with the requirements of the work program, but not later than 6 weeks after commencement of the Works, provide, equip, maintain and staff the laboratory at Site or as otherwise approved by the Engineer.

The Contractor shall provide a detailed list of proposed testing apparatus and materials to the Engineer for approval, prior to ordering.

The providing of the site laboratory includes:

- construction of the building
- supply of equipment (which shall include at least the items of equipment required for tests) and furniture
- maintenance, daily cleaning and security
- servicing including the supply of water, electricity, chemicals and all consumable materials required for conducting the tests correctly

The site laboratory shall be maintained by the Contractor until completion of the Works or for such additional period as instructed by the Employer or the Engineer.

On completion of the Works, the laboratory and its equipment shall remain the Contractor's property.

The laboratory shall be provided with a complete documentation of Standards relating to the tests to be performed.

The Contractor shall, at all times, ensure the Engineer's free access to the laboratory for checking or executing separate tests on materials used or to be used in the Works, and shall
afford every facility in this respect, including the use of the equipment, assistance of staff and the provision of samples for tests where called for.

1.5.2 Laboratory Staff

The Contractor shall employ full-time a highly qualified Quality Controller, who shall be responsible for quality control and quality assurance on Site and shall lead and coordinate the work of the site laboratory.

The Quality Controller shall be an engineer with a minimum of ten years quality control or quality assurance experience with a minimum of two years in supervision or management, or combined education, experience and training acceptable to the Engineer. Qualifications of the proposed Quality Controller shall be submitted to the Engineer for review and approval. At the option of the Engineer, the proposed Quality Controller shall be subject to personal interview by the Engineer prior to approval.

The Quality Controller should not be changed or replaced without the written approval of the Engineer. The Engineer may request the Contractor to replace the Quality Controller and the Contractor shall immediately comply, at no additional cost.

For the entire operational period of the site laboratory highly qualified staff, experienced with the tests to be performed for the Works. This shall include at least:

- material and soil testing engineer or technician
- concrete engineer or technician
- adequate number of laboratory technicians, experienced in sampling and testing methods applicable to the Works

Either the material and soil testing engineer or the Quality Controller himself shall be responsible for managing the laboratory, for keeping proper records and stores and for the correct performance of all testing and subsequent reporting. The concrete engineer/technician shall be a specialist familiar with the technology and manufacture of concrete.

The qualification and extensive and specialized knowledge of both engineers/technicians shall be attested by a suitable qualification in the form of a certificate or diploma issued by a recognized body.

1.5.3 Equipment Standard
1. General Specification

All equipment shall be in accordance with the standard of testing referred to in the respective Sections of the Technical Specifications.

All equipment shall be new and correspond to the metric system.

The test equipment shall include any materials required to run the tests, calibration devices, an adequate number of sample forms, spares, etc.

Prior to initial commencement of any testing and subsequently at suitable intervals, all equipment and apparatus shall be checked for correct functioning and calibrated or replaced, as appropriate, all at Contractor's expense.

1.5.4 Laboratory transport

The Contractor shall provide for the exclusive use of the laboratory a suitable vehicle able to transport the equipment and the required personnel for on-site tests and the samples to be sent to the laboratory.

1.5.5 Tests to be Performed

The site laboratory shall be equipped to perform at least the following main tests in accordance with the Standards as required by the respective Sections of the Technical Specifications.

Soil testing:

- particle size analysis (sieve and hydrometer analysis)
- Atterberg limits
- water content
- organic content
- direct shear test
- oedometer (consolidation) test
- permeability test
- relative density test
- modified proctor test
- load plate test (if required or directed by the Engineer)
- in-situ density tests, such as cutter cylinder, sand replacement method or densitometer (water balloon test)
Detailed Design for Muvumba Multipurpose Dam

- radiometric sounding (Troxler probe) for in-situ measurement of density and water content (if agreed with the Engineer)

**Concrete testing:**
- particle size analysis of concrete aggregates
- determination of settle able solids
- moisture content of aggregates
- check of cement content of fresh concrete
- determination of mix proportions of fresh concrete
- measuring of consistency (workability)
- bulk density after compaction
- determination of voids content of fresh concrete
- compressive strength (size of test specimen 20 x 20 x 20 cm)
- water tightness tests
- non-destructive testing

**Cement and grout testing:**
- Cement setting time, blain fineness, heat of hydration, strength
- Design and checking of grout

In case, the Contractor intends to perform particular tests (e.g. oedometer test, organic content) not at Site but by an independent laboratory, he shall give written notice to the Engineer. Any laboratory sub-contracted by the Contractor are subject to the Engineer’s approval.

The required capacity of the site laboratory (number of test apparatus, laboratory staff, etc.) and/or of sub-contracted laboratory shall be ensured at any time, i.e. also at peak times.

The Contractor shall make arrangements for performance of any test, which will be necessary in the opinion of the Engineer, without any extra payments.

**1.5.6 Record of Test Results**

The form of test reports shall be coordinated by the Contractor with the Engineer.
1. General Specification

Test reports are to be handed over to the Engineer on the date of testing.

A Record Book of tests and results shall be kept by the Contractor, and made be available to the Employer and the Engineer at any time. Upon completion of the Works, the Record Book shall be handed over to the Engineer.

1.5.7 Laboratory Building

The laboratory building provided and maintained by the Contractor for the duration of the Contract shall be located near to the Engineer’s site office.

Details of the Contractor’s proposed location and layout of the laboratory shall be submitted to the Engineer for approval before its construction starts.

The laboratory building shall cover a minimum area of 100 m² and comprise:

- general entrance area to receive samples
- area for preparation of materials and trial mixes
- 1 room reserved for concrete tests
- 1 room reserved for test on mineral construction material (soil)
- 1 room with floor area of 6 m² with saturated and air-conditioned atmosphere at 20°C and 6 m³ tank with controlled temperature at 20°C for conservation of the concrete samples
- 1 room air-conditioned at 20°C for tests requiring such conditioning (eg cement tests)
- adequate furniture for all rooms (tables, chairs, benches, shelves and cupboards, etc.)
- running water (i.e. sinks with a piped water supply and drain), wired for electric light and power, with sufficient light and power points for the efficient use of the equipment. Contractor shall ensure a continuous supply of electric power and water to the laboratory at all hours including nights, weekends and public holidays
- the laboratory shall be watertight, weatherproof and insect-proof, properly ventilated, heated
- 1.6 Setting out and site survey

Reference points and benchmarks of the existing survey used in the design will be handed over to the Contractor by the Employer / the Engineer before commencement of the Contractor’s survey works.
The Contractor shall provide necessary skilled and experienced engineering personnel to execute both, setting out and construction survey works. He shall provide all instruments and equipment which are accurate and suitable for the surveys and in proper condition and calibrated.

The Contractor shall furnish all necessary surveys, including all lines, grades and elevation, for the dam and apparent structures, such as spillway, bottom outlet, roads, etc. and for the irrigation and drainage networks, and all other works according to the Drawings.

1.6 Setting Out

In accordance with the supplied Drawings, the Contractor shall carry out:

- establishment of the general axes
- setting out of the works
- setting construction stakes as necessary for establishing lines, grades and elevation according to the specifications hereafter and/or as specified by the Engineer:
  - Site reconnaissance in the presence of the Engineer
  - Identifying existing benchmarks and reference points in the field
  - Staking of the works (with stakes out of wooden or steel) in the following way:
    - 1 stake every 50 m in straight lines, or at least 2 stakes
    - 1 stake at each angle
    - 1 stake with each entry and exit of curve
    - 1 stake every 25 m in the curves
    - 1 stake with each intersection

The Contractor shall notify the Engineer and the Employer at least two working days in advance of the beginning of any surveys, so that they may witness the survey work.

The stake-out shall be subject to the approval of the Engineer before commencing the construction works. If, in the opinion of the Engineer, any modification of the lines or grades is advisable, either before or after stake-out, the Engineer will issue detailed instructions to the Contractor. The Contractor shall revise the stake-out for further approval. Notwithstanding the possible checks of the Engineer, the Contractor will be solely responsible for the setting out.

The tolerances of setting out shall be according to Table 2. Such tolerances cannot
supersede stricter tolerances required by the Drawings or Technical Specifications, and cannot otherwise relieve the Contractor of his responsibility for the measurements in compliance therewith.

X and Y: tolerance measured in a horizontal plane, according to the axis of layout, and in perpendicular direction

Z: tolerance in altitude

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<th>Table 1.6-1 Setting out – tolerances</th>
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<tbody>
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<td><strong>Description</strong></td>
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<td>Canals (axis)</td>
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<td>Works</td>
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The Contractor shall submit to the Engineer the coordinates of all benchmarks / stakes as well as layout plans.

The Contractor shall be responsible for protecting all benchmarks and stakes (principal and secondary). He shall restore or replace them, in particular if the work progress does not allow preserving them. Any cost associated with replacement if damaged, regardless of the cause, shall be the responsibility of the Contractor. The Contractor shall also bear the cost of providing and safeguarding any additional control points which may be found necessary during the Works.

If considered necessary by the Engineer, the Contractor shall install additional permanent benchmarks at certain locations along the project.

### 1.7 Routine Construction Survey Work

The Contractor shall perform routine construction survey work necessary for the execution of construction works in accordance with the Drawings, for detailed measurement of the Works for payment, and for drafting construction records and as-built drawings.

This shall include but not limited to the following surveys:

- survey details for the dam, the spillway and bottom outlet structures, roads, etc.
- longitudinal section (raised) and cross-sections of the dam and the spillway, bottom outlet structures, and roads, etc.
The distance between two points of the longitudinal profile shall be at least 25 m. Except contrary indication, all surveys shall be attached in altitude to the topographic points envisaged in preliminary work. The carry forwards will be made on suitable scales allowing a good legibility of the plans. Where required, the Contractor shall take cross-sections of the dam, roads and channels, etc. on the original ground at intervals of 50 meters or less, as directed by the Engineer.

Profiles (longitudinal and cross-sections) shall include both, the proposed finished lines and the lines according to Tender and/or the Working Drawings.

The Contractor’s surveys are part of the Work and may be checked by the Engineer any time. The Contractor is responsible for any lines, grades, or measurements which do not comply with specified or proper tolerances, or which are otherwise defective for any resultant defects in the Work. The Contractor will be required to conduct re-surveys or check surveys to correct errors.

The Contractor’s routine survey work for Works measurement requires not only geometric measurement using precise levels, theodolites, tapes, chains, etc. but also the measurement of fill / backfill thickness of the embankment and other works e.g. by auger drilling or settlement plates, and all such other methods of work volume measurement as required by the Engineer and/or Volume IV of the Tender Documents.

1.8 Surveys for Measurement for Payment

The Contractor shall perform the surveys, including control surveys for establishing the measurement reference lines and submit to the Engineer record (as-built) surveys for the following items:

- natural ground level before excavation / filling works
- subgrade following excavation
- final surface of embankment
- limits of geotextiles (surface area)
- final lines, grades and elevations of pipes, trenches, ditches, canals / channels, etc.

Where measurement for payment of the Works requires material volumes to be determined as the difference between the after-construction (or design) profile and the existing before-construction profile, the Contractor shall carry out - as a part of his routine construction survey work - all necessary topographic surveys in sufficient detail to enable the work volumes to be accurately calculated.
1. General Specification

The Contractor shall submit survey information for all items for which such measurements are required to the Engineer before covering the items, such as:

• volume of excavation

• volume of filling and backfilling, including embankments and specified for each material

• area (corrected for slope) of geotextiles in the embankment

• volume of embankment and excavation for roads and other work areas

The Contractor shall provide all records, calculations, drawings, etc. in digital version to the Engineer for cross-checking of quantities for payment purposes.
2. Soil and Geology Specification

2.1 Site clearance

2.1.1 Clearing of Trees

This work comprises grubbing of trees and vegetation, including clearing, removing, loading, transporting and disposing within the limits of construction as shown on the Drawings or as designated by the Engineer.

The Contractor shall clear the parts of the Site subsequently to be occupied by the Permanent Works and shall maintain them clear of vegetation.

Parts of the Site not occupied by the Permanent Works shall be cleared as far as needed for construction works (including borrow areas). Cavities and losses of soil which result from clearing shall be filled and made good with appropriate materials.

In areas occupied by the Permanent Works, termite hills and small mounds (i.e. ground adjustments), and generally materials (bricks, stones, etc.) likely to disturb circulation or works shall be removed and deposited separately from any excavation material and at locations approved by the Engineer.

The cleared materials (including stumps, roots, branches, brush, weeds and other perishable material) as well as all debris resulting from the clearance works (including broken branches, fallen leaves, wood chips and sawdust) shall be promptly removed from the work site. Burning of any material shall not be allowed, unless explicitly admitted by the Engineer.

The Contractor shall not clear the Site of any structure without prior written permission of the Engineer. However, the Engineer can demand to clear a larger area by issuing a written order.

Trees and vegetation outside of construction area shall be protected from damage by the Contractor. In case of trees and vegetation outside of the construction site or those not designated for cut / removal are damaged or destroyed the Contractor is obliged for rehabilitation or compensation.

Devices / equipment for tree cutting:

For the execution of Works should be used: handsaw (and/or careful working with chain-saw), bulldozers, diggers, graders, wheeled tractor, grubbers, rotary mowers, equipment for grind branches and leaves, or other equipment approved by the Engineer.

Removing of trees:

Trees shall be defined as having a trunk diameter of 5 cm and greater measured at a height
of 1 m above the ground. Shrubs shall be defined as single or multi-stem individual plants, not of tree size.

Trees and shrubs shall be uprooted or cut down as near to ground level as possible and trimmed whenever directed by the Engineer. Trunks shall be cut to a length of 2 m.

Removed trees and shrubs are not the property of the Contractor but a public good managed by the local authorities. They should be removed outside the limits of the construction works to a dry and fenced area, where they are stockpiled until handover to the third party indicated by the Engineer. Costs for guarding and securing the store place are deemed to be included in rates for site clearance.

**Grubbing-up roots:**

Removal of existing trees shall include removal of tree stumps and tree roots 5 cm or larger in diameter to a minimum depth of 40 cm below the grading plane. Stumps and tree roots shall be grubbed up, blasted, removed and disposed of in approved dumps to be provided by the Contractor.

The holes resulting from grubbing up shall be backfilled with approved materials, which shall be deposited and compacted in layers not exceeding 25 cm (not compacted) thickness, to the same dry density as that of the adjoining soil.

The root system should be kept in place as far as possible to assist in later erosion control. However, if they need to be removed, best cleaned around the root with a high pressure water jet before extraction, then the exposed smaller roots are severed, and the whole root taken out in one piece, disposed of in approved dumps to be provided by the Contractor.

**Trimming of trees:**

On trees or shrubs designated to remain as defined by the Engineer, low hanging branches shall be removed, where those are directly hindering the construction activities by blocking the access of construction machinery. Only in these locations branches of trees shall be trimmed to give the clear height of 5 m above the Site.

**Bushes and hedges:**

All bushes and hedges, the main stem of which is less than 500 mm girth at 1 meter above ground level shall be uprooted (unless otherwise directed by the Engineer) and disposed off as directed by the Engineer.

**Vegetation and debris:**

Vegetation designated for removal, such as weeds, grass, shrubbery, roots, and stumps, and debris, shall be removed from construction areas and disposed of by the Contractor. Vegetation to remain shall be protected in place.
2. Soil and Geology Specification

2.1.2 Removal and spoiling of top soil

Topsoil is defined as the surface or top layer of soil, including fine roots, the herbaceous vegetation and overlying grass and characterized by the presence of organic matter. Immediately after clearing operations and before excavation commences, the Contractor shall remove topsoil, where and to such depth as directed, from the surfaces of the borrow areas, the stockpile sites, the areas to be backfilled, and the areas of the Works where surface excavation is required. Removal of topsoil from disposal areas will not be required unless insufficient topsoil is available from required excavation to meet the requirements of the Specification. Topsoil shall be removed within 2 m outside the limits of required excavation and the surface shall not be disturbed beyond these limits.

2.2 Earthworks

2.2.1 General

The general requirements (principles of earthworks) - as described in the following Sections of the General Technical Specifications - shall be applied and shall be valid for all earthworks to be performed under the Contract. This includes the dam embankment, trenches, including the core trench of the dam and the diversion channel, foundations of any structures, as well as surface drains and subsoil drains, etc.

The Contractor shall perform all surface excavations, and procure construction materials from required excavation, in accordance with the proposals approved in the Letter of Acceptance or with such modifications as may be approved from time to time.

Suitable material from surface excavations shall be used in the Works. The Contractor’s blasting and other operations in the excavations shall be such that the materials excavated will yield as much required suitable materials as practicable, and shall be subject to approval. Where practicable, materials suitable for use in the Works shall be excavated separately from materials to be wasted. Approved material shall be segregated by loads during the excavation and shall be placed in the designated final locations or shall be placed in stockpiles and later placed or processed and placed, in the designated final locations, in accordance with the provisions of this Specification.

Such material actually placed in that Works will also be included for payment under appropriate items of the priced Bill of Quantities covering such construction.

The suitability of material obtained from the required excavations for use in the Works will be determined by the Engineer.

If, by reason of the Contractor not using all material from required excavation which is suitable and required for the Works, it is necessary to obtain material from other sources, the Contractor shall obtain, at his own expense, a quantity of material equal to the quantity of suitable material from required excavation wasted by him, as determined by the Engineer.
Any and all over-excavation performed by the Contractor for any purpose or reason, except as may be directed and whether or not due to the fault of the Contractor, shall be at the expense of the Contractor. All such over-excavation shall be backfilled with approved material from required excavation or concrete, as directed, and the cost of furnishing and placing of this backfill shall be at the expense of the Contractor. The Engineer may approve alternative measures to backfilling and the cost of such measures shall be at the expense of the Contractor.

2.2.1.1 Equipment and Earthworks Machines

The Contractor shall provide all machines, equipment, plant, labour and materials required for such work and all costs incurred shall be deemed to be included in his rates for the earthworks.

Any equipment, machinery and devices which do not comply with the requirements ensuring the quality of work will be disqualified by the Engineer and will not be allowed for works execution.

For works execution shall be used: bulldozers, backhoes, graders, compaction machines, such as smooth drum roller, sheep-foot rollers, vibrating roller or hand compaction equipment (vibrating plates, hand panners), and other equipment (sprinkler, scarifier) approved by the Engineer. In case towed rollers are used which are pulled by tractor, then the tractor has to be adequately powered to work satisfactorily when the roller is fully loaded (drum weight approx. 15 ton).

Earthworks machine employed at Site shall be in accordance with the Contractor’s machine list as in his offer (type, manufacturer, power, capacity, year of manufacturing / age – any deviation need to be approved by the Engineer).

The operational conditions, maintenance and repairs of machines and equipment are in responsibility of the Contractor. The Contractor is obliged for having all time machines and equipment with sufficient capacities on Site required for works realization according to the contractual works schedule.

2.2.1.2 Transport

The Contractor is obliged to use only such means of transport, which do not adversely affect the quality of the Works and not adversely affect the materials suitability and their mechanical properties. Number of transports and transport capacities to organize by the Contractor shall ensure keeping the Works in accordance with the requirements set out in the Technical Specifications and the Drawings - and further contractual stipulations (machine list, works schedule and to ensure the contractual time for work’s execution to date as
provided in the Contract; and others). At any time the Engineer can order to remedy and/or increase capacity of transport facilities – when transport facilities are not in accordance with the contractual requirements.

Transport vehicles and machinery, which do not meet the conditions of the Contract, shall be removed from the Site on request of the Engineer.

2.2.1.3 Material

The Contractor shall make all necessary arrangements for locating, selecting and processing of construction materials in accordance with the Technical Specifications.

At least 4 weeks before exploitation of any borrow area the Contractor shall submit full information regarding the proposed material source (including location, material specification, expected quantity, and purpose of use, etc.) to the Engineer for approval. Approval of a material source does not imply that all the material in that source is approved.

The Contractor shall organize all related administrative permits or permits from land owners of such borrow areas.

Material requirements, such as mechanical and physical properties, are specified in the General or Particular Technical Specifications of respective Works.

Construction materials from excavation works which can be re-used (after approval of the Engineer) are to stockpile separately.

2.2.1.4 Disposal of Excavation Materials

Excavated material not required for the Works shall be hauled and disposed of frequently and regularly (at least once per day). The disposal location shall be outside the limits of the construction works. The locations proposed by the Contractor, whether temporarily or permanently, shall be subject to the approval of the Engineer.

Permanent disposal locations shall be landscaped to the approval of the Engineer.

In case the disposal location is outside of the construction site, and public roads are used for transports, the Technical Specifications for transports on public roads shall be regarded.

Material shall be deposited in such places and in such a manner as not to cause damage to roads, services or property either within or outside the limits of the construction works, and not to cause impediment to the drainage of the Site or surrounding area.
2.2.1.5 Temporary Material Storage and Stockpiling

In regard of location, rules and conditions for storage and stockpiling of mineral construction materials (soils, stones and aggregates) and other construction materials the Contractor’s mobilization plan shall be followed.

The Contractor shall ensure that temporary storage of soil materials until its re-use is secured in a manner ensuring materials quality (mechanical properties, cleanliness) for its use within the earthworks performance.

Places of temporary storage of materials shall be located within the construction site, but outside of construction zones foundation area and outside of areas needed for temporary works, as agreed by the Engineer. In case the Contractor decides for an own determined storage place and is approved by the Engineer – the Contractor shall care for all necessary administrative permits, has to work in accordance with the applicable law and regulations (e.g. environment law, land ownership rights). In case the Contractor decides for outside located material storage or stockpiling – this shall not entitle the Contractor for extra payments and not for any extension of construction time.

Transportation of bulk and dust emitting materials / soils shall be carried out in a manner avoiding negative impact on environment and people. Further, temporary storage areas shall be sprayed periodically, so that dust transmission is avoided.

The Contractor shall performed stockpiling in such a manner that the quality and soil-mechanical parameters of the stored materials is ensured for it’s re-use, i.e. for example protection from saturation.

The Contractor is not entitled for any extra payments for any of his activities related to temporary material storage and stockpiling.

2.2.2 Testing of Mineral Construction Material

2.2.2.1 Suitability Tests

The Contractor shall provide reports on “suitability tests” of mineral construction materials for all filling / backfilling works.

If not otherwise specified in the Particular Technical Specifications, one test series shall be performed on material samples from every used outside source and one test series from the profiling / excavation works at Site if foreseen for the use as filling material.

- The test program shall enclose at least:
  - combined sieve / hydrometer analysis
  - Atterberg limits
• water content
• organic content
• direct shear test
• Oedometer test (unconfined compressive strength)
• permeability test
• relative density test
• modified proctor test

Direct shear tests, Oedometer tests and permeability tests shall be performed on samples prepared with proctor density (i.e. maximum dry density) and optimum water content.

Acceptance of material from any particular borrow location shall not be considered as approval of the entire location but only in so far as the material continues to meet the specification requirements.

Additional tests may be required by the Engineer.

2.2.2.2 Routine Tests

During the construction works routine tests shall be performed according the requirements and test frequency of respective Section of the Particular Technical Specifications.

The test program shall enclose at least following laboratory:

• combined sieve / hydrometer analysis
• Atterberg limits
• water content
• direct shear test
• permeability test
• compaction degree

Direct shear tests and permeability test shall be performed on samples taken from the filling area (e.g. by cutter cylinder).
Additional tests may be required by the Engineer.

2.2.2.3 Compaction Tests

During the construction works routine compaction tests shall be performed according the requirements and test frequency of respective Section of the Particular Technical Specifications.

The test program shall enclose at least:

- Load plate test to determine $E_{v2}$ and $E_{v2}/E_{v1}$ values
- Cutter cylinder, sand replacement method and/or densitometer (water balloon test) to determine the Field Dry Density
- Relative density test to determine the in-place density as compared to minimum and maximum void ratio or dry density
- Radiometric sounding (Troxler probe) for in-situ measurement of density and water content TP BF-StB, Teil B 4.3, (ASTM D 6938)

The degree of compaction in [%] is defined as ratio of Field Dry Density over Laboratory Maximum Dry Density.

with: Field Dry Density (hereinafter referred to as “density”) equals the average of results of all field compaction tests to determine field dry density to date, for each material type.

Laboratory Maximum Dry Density (hereinafter referred to as “proctor density”) equals the average of results of all (modified) proctor tests to determine Proctor Maximum Dry Density to date, for each material type.

Radiometric sounding (Troxler probe): If not otherwise specified, the compaction control for the dam embankment can be performed by radiometric sounding (Troxler probe). At the beginning of the earthworks, the Troxler probe must be calibrated in a test field (separated fields for core and shell materials). Additionally, for continuously verification of the Troxler probe about 20 % of the compaction control shall be performed by conventional methods, i.e. load plate test, cutter cylinder, sand replacement method and/or densitometer (water balloon test).

Additional tests may be required by the Engineer.

Separate compaction records shall be kept for materials of differing properties.
2. Soil and Geology Specification

2.2.3 Stripping of Topsoil

The Contractor shall strip the topsoil from areas to be occupied by the Works. The stripped topsoil shall be stored in triangular heaps, separately from other excavated material until its final disposal by spreading and leveling elsewhere on the Site and/or as specified or ordered by the Engineer.

Where the Temporary Works will not be subsequently covered by the Permanent Works, or by the reservoir after impounding, the Contractor shall strip the topsoil to the full depth (not exceeding 0.5 m) and store it on-site (in triangular heaps, height not more than 2 m) separately from other excavation materials.

Disposal location needs approval by the Engineer.

2.2.4 Excavation Works

This work shall include any kind of excavation works under this Contract, such as foundation pits for civil structures, the dam core trench, the trench for laying the bottom outlet pipeline, as well as other trenches and canals, etc.

Following classification shall apply for the descriptions given in the Technical Specifications:

Rock:

Rock shall mean a hard compact natural formation which in the opinion of the Engineer can only be removed by the prolonged and persistent use of pneumatic tools, or by sledge hammer and wedges, or by the use of explosives.

Soft rock:

Materials which can be excavated by hand with pick and shovel or can be machine ripped (by a tractor not larger than caterpillar 08 or machine of similar capacity) prior to excavation.

Soils:

Overburden, loose soils over groundwater aquifer or below groundwater aquifer (water saturated soils, possibly liquid), which can be excavated by earthworks machines in accordance with the Contractor’s machine list (bulldozer, backhoe, wheeld loader, etc.) and if necessary with support of pumping and dewatering measures.

2.2.4.1 Excavation in Soil and Rock

Excavation, which is to remain open permanently, shall be carried out to the limits, lines,
grades and levels shown on the Drawings. Otherwise, the extent of any excavation shall be reasonably justified by the Contractor and be subject to the prior approval of the Engineer.

The excavation depth (i.e. level of the bottom of foundations) shown on the Drawings may deviate depending on the geotechnical soil conditions encountered. The Engineer may instruct in writing such changes in levels or dimension as may be deemed necessary.

Excavation, which is to remain open only temporarily, shall be carried out in such a manner as to permit the proper execution of the Permanent Works. Excavation in soils shall ensure stable side slopes or slopes / construction pits shall be adequately supported (e.g. by pit lining, sheeting, timbering or bracings) at the Contractor’s own.

For excavation, which needs to be performed on limited working space, the Contractor shall employ suitable machines for such work.

At least 7 days before commencing (or recommencing) of any excavation, the Contractor shall give written notice (including the proposed start date) to the Engineer. Within this period an agreed topography survey of the undisturbed ground levels shall be made for the measurement of the Work.

After excavation works the Contractor shall notify the Engineer for approval of the excavation works. No face of any excavation shall be covered before it has been approved by the Engineer

After excavation and along the time till continuing the construction works the foundation area shall be kept clean, dry, free of mud or soft soil and loose stones or any organic matter. Boulders, logs and other objectionable materials encountered in excavation shall be removed.

In soft excavation the exposed faces shall be trimmed to the required profiles. In rock excavation the face shall be trimmed so that no point of rock protrudes within the required "Payment Line". All excavation surfaces against which concrete is to be placed shall be even and firm

Any over-excavation shall be backfilled with approved material as specified elsewhere and/or as instructed by the Engineer, at no extra cost to the Contract.

Where a structure or embankment is to be founded on sound ground, not necessarily rock, the excavation shall be taken down until the required formation is exposed. All loose soil, turf, organic soil and peat being shall be removed.

The excavation bottom (natural ground) shall not be disturbed. Therefore, excavation and trimming to final level shall be executed immediately before placing the Permanent Works upon it. If not otherwise specified the Engineer, the last 15 cm shall be excavated and trimmed by hand.
When a structure or embankment is to be founded on rock but does not require penetration into it, all soft overburden shall be removed and the surface of the rock cleared of any loose material of rock by barring and wedging.

Where the foundation calls for penetration into the rock, the excavation of the rock may be carried out by blasting. The explosives shall be used in such a manner as to prevent the shattering of the rock. Loose or shattered rock shall be removed by picking, barring and wedging so that the exposed surface is sound.

For further specifications on preparation works for foundations, it is referred to Section 2.2.5.

Any necessary ramps or access into excavation pits, trenches or channels are in the responsibility of the Contractor and any expenses are to include in the unit rates for excavation.

Profiling and according trimming works of slopes are to include in the unit rates.

Every precaution shall be taken to avoid causing damage to any structure. Any damage so caused shall be made good by the Contactor as soon as practicable, at no extra cost to the Contract.

### 2.2.4.2 Excavation Support

The Contractor shall provide any excavation supports necessary to ensure the safety of the Works and to protect any roads, buildings, bridges and other properties in the vicinity thereof from damage.

When required, the Contactor shall submit his Method Statement for such excavation support to the Engineer. If, in the opinion of the Engineer, the support proposed by the Contractor is insufficient, then the Engineer may order the provision of a stronger support to be provided by the Contractor. The Contractor shall make no charge for providing such stronger support.

Excavation and trench supports shall not be removed until, in the opinion of the Engineer, the Permanent Works is sufficiently far advanced to permit such removal.

In cases where the ground is unstable or where the Engineer considers it necessary, excavations and trenches shall be close timbered from top to bottom.

Sheeting or timbering shall be designed in such a way that removing of the support elements is possible when backfilling takes place to ensure complete backfilling, i.e. the backfill shall be in contact with the pit or trench walls.
2.2.4.3 Slips and Falls

The Contractor shall prevent any slips and falls of material from the sides of excavations or trenches or adjacent embankments / slopes.

In case slips and falls occurred, the Contractor shall remove any slurry or disturbed material. Any voids resulting from slips or falls or resulting from excavation which is made in excess of the dimensions of the Permanent Works shall be filled.

When such voids occur in rock and, in the opinion of the Engineer, may affect the stability of the ground, slopes, or adjacent structures and services, the Contractor shall fill the void solid with concrete of the same class as the adjoining structure.

In other cases, the Contractor shall fill the voids with selected excavation material. The material shall be placed and compacted to the full satisfaction of the Engineer.

The Contractor shall make no charge for additional payment in respect of filling such voids.

2.2.4.4 Excavations to be kept dry

All excavations (foundation pits, trenches, etc.) shall be kept free from water (from whatever source, e.g. surface water, run off flows), so that the Works shall be constructed in dry conditions (unless otherwise approved; such approval will only be given in exceptional circumstances). Water shall be diverted and properly managed by pumping or wellpoint dewatering, or temporary drains, etc. at all times during the construction, inspection and testing.

The Contractor shall maintain the water level below the bottom level of the permanent work by such methods, to such depth and for such duration as the Engineer may approve. Where the method approved by the Engineer involves the use of mechanical plant, the Contractor shall maintain on-site in working order as much stand-by plant (e.g. pumps) as necessary to ensure the safety of the Works.

All required provisions for dewatering and pumping will not be paid extra, and shall be included in the unit rates.

Before commencing any dewatering / draining works, the Contractor shall submit his Method Statement for the Engineer’s approval. Besides the proposed temporary dewatering / draining measures, the Method Statement shall comprise the method and position of disposal of water from the excavations.

In case the Contractor intends to construct temporary drains, this shall be described in detail in the Contractor’s Method Statement. The Engineer may permit them to be constructed below the level and within the limits of the permanent work.
Any provision that the Contractor makes below the permanent work shall, if left in place, be made to provide support at least equal to the permanent support. No drain pipes shall be left in unless they are filled with concrete or other approved material.

2.2.4.5 Explosives and Blasting (Provision)

The Contractor shall at all times take every possible precaution and comply with the Explosives Laws of Rwanda and regulations relating to the handling, transportation, storage and use of explosives and shall at all times when engaged in blasting operations post sufficient warning flagmen to the full satisfaction of the Engineer.

The Contractor shall at all times make full liaison with and inform well in advance and obtain such supervision and permission as is required from the Police and all Government Authorities, public bodies and private parties whosoever concerned or affected by blasting operations.

Blasting shall only be carried out on those sections of the Works for which permission in writing shall have been given by the Engineer and shall be restricted to such hours and conditions as he may prescribe. Such permission shall not be withheld nor such hours and conditions imposed unreasonably.

The greatest care shall be taken in the use of explosives, the charges being so placed and of such amount as in no way to weaken existing structures or the foundations or ground adjacent to the existing and proposed works. The Contractor shall take all necessary precautions to prevent loss, injury or accident to persons or property and shall be entirely liable for any accident or damage that may result from the use of explosives.

The Contractor shall submit a Method Statement to the Engineer for his approval including the intended drilling patterns, depths of holes, the amounts of explosives at each location and the method or sequence of detonation that he proposes to use. The Engineer may find it desirable to direct the Contractor to use special methods to obtain sufficient, even and undamaged rock surfaces.

Storage and handling of explosives:

The Contractor shall provide a special store for explosives in accordance with Rwandan Regulations. The Contractor shall provide experienced men with valid Rwandan blasting licences for handling explosives to the satisfaction of the Engineer and the Authorities concerned.
2.2.5 Preparation Works for Foundations

This work shall include any kind of preparation work for foundations, such as embankment foundations, foundations of civil structures, etc.

Foundation levels shall be carried out to the lines, grades and levels shown on the Drawings, unless otherwise specified by the Engineer due to the geotechnical soil conditions encountered.

The natural ground at foundation levels shall not be disturbed. Therefore, excavation and trimming to final level shall be executed immediately before placing the Permanent Works upon it. If not otherwise specified the Engineer, the last 15 cm shall be excavated and trimmed by hand.

Rock surfaces shall be thoroughly pruned by air pressure or high pressure water treatment (hand works) or other suitable means before placing the Permanent Works upon it.

2.2.5.1 Excavation and Replacement of Unsuitable Material

Excavation of unsuitable material shall be removed to the limits indicated on the Drawings or until suitable bearing soils are encountered as determined in the field by the Engineer, or whenever the Engineer founds the soil to be unsuitable.

Unsuitable material shall be disposed outside of the construction area and/or as directed by the Engineer.

Unsuitable material include those soils which are encountered in foundation areas after stripping and which are in-situ classified by the Engineer or shown on the Drawings as being unacceptable for the foundation of civil structures or embankments.

Unsuitable material are soils containing vegetation, roots, topsoil or other organic material, miscellaneous debris, uncontrolled fill from previous other works, or excessive moisture and any soils listed below:

- liquid silt, peat, polluted soil, slurry or mud
- clay and silt with high organic, i.e. organic content > 5 %
- highly plastic clay, i.e. liquid limit \( \geq 50 \% \) or plasticity index \( Ip \geq 35 \% \)
- soft soils or dominantly silts (silt fraction > 40 %)

Unsuitable material shall be removed mechanically using backhoes, graders, or bulldozers. In exceptional situations where the use of machines is not sufficient for proper execution of the Works, or may constitute a danger to security works, manual execution of the works with
suitable tools may be required.

Unsuitable soil shall be replaced by well graded gravelly, sandy soil free from organic (organic content < 3%) and suitable water content for compaction as specified in Section 2.2.6 of the General Technical Specifications or as approved by the Engineer.

For the dam foundation, shell respectively core material shall be used for replacement as defined in Sections 2.6.3 and 2.6.4 of the Particular Technical Specifications.

Fill material must be placed and compacted in layers not exceeding 15 cm compacted thickness, or as directed by the Engineer. At foundation level, a compaction degree of $D_{pr} \geq 95\%$ (modified proctor) shall be achieved if not otherwise specified elsewhere.

Excavation and replacement of soil to a depth of up to 0.5 m below NGL is defined as part of the site clearance works and shall be considered by the Contractor hereunder. Excavation and replacement of soils to a depth of more than 0.5 m below NGL are accordingly included in the BoQ items for shell or core zone material, or whatever is applicable.

2.2.5.2 Treatment of Unsound Material

Unless otherwise specified or ordered by the Engineer, the Contractor shall fill voids in foundation areas. For foundations of civil structures, concrete of the same class as the adjacent structure shall be used.

If the Contractor encounters any material which is in his opinion unsound, he shall immediately inform the Engineer. The Engineer will instruct the Contractor in writing whether or not the material shall be treated as unsound. Provided that if in the Engineer's opinion the unsoundness of the foundation is due to the Contractor's method of working or his failure to keep the excavation free from water, the removal, disposal and replacement of unsound material shall not be measured for payment. The omission by the Engineer to give an instruction shall not relieve the Contractor from any responsibility for defects in the Works, if prior to construction the Contractor shall have failed to request the Engineer, in writing, to inspect the exposed foundation.

2.2.5.3 Acceptance of Foundation areas

After completion of the excavation and preparation work for foundations, the suitability of the area needs written approval by the Engineer. Due notice shall be given to the Engineer to enable him to examine the foundation before placing the Permanent Works upon it. The Contractor shall provide test reports (laboratory and/or field tests) proving sufficient compaction degree of $D_{pr} \geq 95\%$ (modified proctor), or as specified in the Particular Technical Specifications, on the Drawings or as directed by the Engineer.
In case of detection of any loose or otherwise unstable soil materials, these areas shall be re-compacted. If these materials cannot be compacted sufficiently then these soils shall be excavated and replaced by suitable material.

If, in the opinion of the Engineer, due to the fault of the Contractor the ground becomes weathered prior to the placing of concrete, the Contractor shall remove the weathered soil and replace it with concrete to the original foundation level at his own expense.

2.2.6 Filling and Backfilling Works

2.2.6.1 General Filling / Backfilling Works

Filling works shall be carried out to the lines, levels and grades required to complete the permanent construction and according to the Drawings.

Backfilling works shall be carried out at spaces excavated under this Specification and not occupied by a permanent structure. This spaces shall be backfilled up to ground level (with due allowance for settlement) prevailing at the commencement of the works (except borrow areas) or to the levels shown on the Drawings, or as ordered by the Engineer.

Should the Contractor fill above the designated levels, the Contractor may be instructed by the Engineer to remove such excess filling entirely at his own expense.

Before commencing the works, the Contractor shall submit his Method Statement to the Engineer (defining construction material, layer thickness, construction / compaction machines, number of roller passes, etc.).

No backfilling shall be placed against any structure until the Engineer has given approval.

After approval by the Engineer, the operation shall start with the minimum delay and shall continue until the work is completed in that part of the works for which the approval is given.

The Contractor shall provide borrow (if necessary to complete the work) with a satisfactory quality and approved by the Engineer. Borrow which is required to replace suitable excavated material used for construction shall not be paid for.

Material:

Backfill material shall be well graded as specified in the Particular Technical Specifications, or on the Drawings or as required by the Engineer. If not otherwise specified, the material shall conform to the gradations in Table 2.2-1 and Table 2.2-2.

Ordinary backfill material:

Ordinary backfill material shall be gravelly, sandy soil with maximum particle size of 50 mm. Backfill against the permanent work shall be selected free from boulders, cobbles, rock
fragments and vegetation, roots, topsoil or other organic material.

If not otherwise specified, filling / backfilling material shall be selected excavated material to the approval of the Engineer.

**Table 2.2-1  Sand backfill Material-According to USCS**

<table>
<thead>
<tr>
<th>soil-mechanical parameter</th>
<th>unit</th>
<th>range of sand backfill material</th>
</tr>
</thead>
<tbody>
<tr>
<td>grain size distribution</td>
<td></td>
<td>fraction</td>
</tr>
<tr>
<td>gravel 4.75~75mm</td>
<td>%</td>
<td>0~10</td>
</tr>
<tr>
<td>sand, coarse 2.0~4.75mm</td>
<td>%</td>
<td>10~20</td>
</tr>
<tr>
<td>sand, medium 0.425~2.0mm</td>
<td>%</td>
<td>35~50</td>
</tr>
<tr>
<td>sand, fine 0.075~0.425mm</td>
<td>%</td>
<td>20~40</td>
</tr>
<tr>
<td>silt, clay &lt;0.075mm</td>
<td>%</td>
<td>&lt;5</td>
</tr>
<tr>
<td>max grain size</td>
<td>mm</td>
<td>50</td>
</tr>
</tbody>
</table>

Granular backfill material:

Granular backfill material shall be crushed stone, crushed gravel, sand or a mixture of crushed and natural aggregates. The material shall not contain clay or lateritic or concretionary materials and shall be free from vegetation and other organic material.

**Table 2.2-2  Granular Backfill Material(Other than Sand)-According to USCS**

<table>
<thead>
<tr>
<th>soil-mechanical parameter</th>
<th>unit</th>
<th>range of sand backfill material</th>
</tr>
</thead>
<tbody>
<tr>
<td>grain size distribution</td>
<td></td>
<td>fraction</td>
</tr>
<tr>
<td>gravel, coarse 19~75mm</td>
<td></td>
<td>0~20</td>
</tr>
<tr>
<td>gravel, Fine 4.75~19mm</td>
<td>%</td>
<td>10~35</td>
</tr>
<tr>
<td>sand, coarse 2.0~4.75mm</td>
<td>%</td>
<td>35~40</td>
</tr>
<tr>
<td>sand, medium 0.425~2.0mm</td>
<td>%</td>
<td>25~30</td>
</tr>
<tr>
<td>sand, fine 0.075~0.425mm</td>
<td>%</td>
<td>5~30</td>
</tr>
<tr>
<td>silt, clay &lt;0.075mm</td>
<td>%</td>
<td>&lt;5</td>
</tr>
<tr>
<td>max grain size</td>
<td>mm</td>
<td>50</td>
</tr>
</tbody>
</table>

Only structures which have contact faces to the core zone of the dam embankment shall strictly be backfilled with core material and comply with material specifications and compaction requirements as defined in Section 2.6.4.

**Execution of Works:**
If not specified differently in the Particular Technical Specification the following criteria shall be fulfilled:

- Scarifying of smooth surfaces when deemed necessary and instructed by the Engineer.

- Filling / backfilling material shall be placed in layers. The thickness of spread layers will range from 15 cm to 30 cm (after compaction) depending on the construction material and the applied compaction machines.

- A minimum of 4 passes of the roller shall be made over the entire area prepared for structural fill placement. Compaction of the lanes by roller shall be done with overlapping of 30 cm.

- The water content shall be in range of +/- 2% of the optimum water content. In case the material is too dry, it needs moistening (with scarifying). In case it is too wet, the spread the material shall be exposed to dry until the required water content is achieved.

- Material which has been compacted to a dry density less than that required by this specification or at moisture content outside the specified range shall be removed or re-worked and re-compacted until the required properties are achieved.

- Each soil layer shall be compacted - as soon as possible after spreading - using equipment corresponding to the type of soil and the prevailing conditions. In case of interruption of works of more than 24 hours the Contractor shall continue earthworks only after inspection and approval by the Engineer.

- Routine tests for checking the compaction effectiveness shall be done all 500 m² backfill works or foundation areas of structures and at places where compaction control deems necessary to the Engineer.

- If the compaction works or re-compaction will not achieve the required compaction degree, then the Contractor shall remove objected layer and build new material unless the Engineer will allow the re-trial proper compaction layer.

Special care shall be taken to prevent any unduly high pressures against the structures.

Backfill shall be placed insofar as possible to approximately the same height on both sides of the structure. If conditions require backfilling appreciably higher on one side, the additional material on the higher side shall not be placed until permission is given by the Engineer or until the Engineer is satisfied that the structure has enough strength to withstand any pressure created.

The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled.
2. Soil and Geology Specification

Unless otherwise specified or ordered by the Engineer, the tops and side slopes of fill shall be neatly trimmed equal to the best practicable finish which can be obtained by the skilled use of earth machines.

Compaction Requirements:

If not otherwise specified in the Particular Technical Specifications or by the Engineer, the following compaction requirements shall be met:

Contact area to concrete structures: ordinary backfill material: $D_{pr} \geq 97\%$ (modified proctor)

granular backfill material: $D_{D} \geq 80\%$ (relative density)

Other locations: $D_{pr} \geq 95\%$ (modified proctor)

Backfilling up to ground levels, outside the Permanent Works: density comparable with the adjacent undisturbed material

2.2.6.2 Pipe Bedding, Side Filling and Backfilling

This work shall include any earthworks connected to the laying of collection and drain pipes. For pipe trench excavation it is referred to Section 2.2.4.

The following shall apply in addition to the General Technical Specifications for earthworks.

Collection pipes (unperforated):

Pipe bedding:

Bedding material shall be well graded, sandy, selected rounded granular material with a maximum particle size of 20 mm and less than 15% fines ($< 0.075$ mm). The material shall be free from stones, lumps, vegetation, roots, topsoil or other organic material.

The trench bottom shall be well rammed. Then, the bedding material shall be placed and compacted to refusal by vibratory plate or roller to produce a base of the required thickness and gradient so that the pipe is uniformly supported on the bedding material. A depression shall be formed on this bed to receive the joint so that the pipe is fully bedded on the barrel.

Side filling:

Collection pipes shall be surrounded with material selected from trench excavation with a maximum particle size of 50 mm.

The material shall be placed in layers not exceeding 20 cm compacted thickness and well compacted by vibrating plate or hand panners to achieve the specified relative compaction. The material shall be brought up evenly and simultaneously on both sides of the pipe to the specified level above the pipe crown. Joints shall be left exposed until the line has been
tested.

**Backfill:**

Backfill material shall be selected material from trench excavation. The material shall be free from large stones, vegetation, roots, topsoil or other organic material.

Backfill material shall be placed in layers not exceeding 30 cm compacted thickness in fields and in layers not exceeding 15 cm compacted thickness beneath roads. Backfill shall be thoroughly compacted to achieve the required compaction degree.

**Drain pipes (perforated / slotted):**

**Filter material:**

Filter material shall be hard, clean gravel or sand, or crushed rock aggregate as specified in the Particular Technical Specifications. The material shall be free from clay, vegetation, roots, topsoil or other organic material.

**Pipe bedding:**

Filter material shall be placed and uniformly compacted by a suitable method approved by the Engineer to form a firm, even bedding as shown on the Drawings.

The pipe sections shall be set firmly against the filter material bedding with the flow lines in design position. For pipes with mating joints, the receiving ends shall be upgrade, and the pipe joints shall be fully mated. For butt jointed pipes with collars, the pipe sections shall be fully contiguous, and the collars properly centered over the joints.

**Side filling:**

Drain pipes shall be surrounded with filter material. The material shall be placed in layers not exceeding 20 cm compacted thickness and uniformly compacted by a suitable method. The material shall be brought up evenly and simultaneously on both sides of the pipe to the level specified on the Drawings.

If not otherwise specified, the filter material shall be surrounded entirely by filter cloth (geotextile). For the closure of the filter layer, the two edges of the geotextile shall overlap at least 25 cm.

Alternatively, the drain pipe shall be tightly wrapped in filter cloth (geotextile) such that the entire length of the pipe is covered. Joints shall have an overlap of at least 10 cm.

Generally, care shall be taken that both, collection pipes and drain pipes, are neither damaged nor displaced. Heavy mechanical equipment shall not be allowed to run over any pipeline until the trench has been completely backfilled and compacted. Above pipes, placing and compaction is allowed only with hand-held equipment or light machines (e.g. vibrating
plate) until at least 1 m cover has been achieved (placing in layers not exceeding 20 cm compacted thickness). Only thereafter (≥ 1 m cover), heavy machines are allowed to use. Generally, construction machines exerting a load excess of 60 t shall not be used within 5 m of the pipe centre line.

Before commencing any pipe works, the Contractor shall submit his Method Statement on pipe laying, including backfilling and compaction method above pipes.

Compaction requirements:

Routine compaction tests shall be performed for each material (i.e. bedding, surrounding and backfill material) for every 25 m trench length for the bottom outlet and every 50 m trench length for other pipes. Following compaction requirements needs to be proven by the Contractor:

Degree of compaction: pipes in the field or minor roads Dpr ≥ 95 % (modified proctor)

pipes in main roads Dpr ≥ 97 % (modified proctor)

2.3 Erosion Protection and Retaining Structures

2.3.1 Stone Pitching (Grouted and Ungrounted/rip-rap)

This work shall consist of the construction of all structures or parts of structures to be composed of stone pitching either grouted or ungrouted (rip-rap) as shown on the Drawings or as directed by the Engineer. Besides others, these may include erosion protection at the upstream dam slope and at the discharge channel at the bottom outlet, canals, drains (e.g. at downstream dam toe), culvert inlets and outlets, or pavements, aprons, etc.

The work shall be carried out in accordance with this Specification and to the lines, levels, grades and dimensions shown on the Drawings and/or as approved by the Engineer. The work shall be carried out and finished all to the satisfaction of the Engineer.

2.3.1.1 Material

Stones

Stones shall be clean rough quarry stones, or pit or river cobbles, or a mixture of any of these materials. Stones shall be essentially free from dust, clay, vegetation, roots and other deleterious materials.

Individual pieces of stone shall be approximately cubical or spherical and shall have dimensions in the range of 10 cm to 30 cm, unless otherwise specified. The stone shall be
hard, tough, durable and dense, resistant to the action of air and water, and suitable in all respects for the purpose intended.

Cement mortar

Cement mortar shall contain 1 part ordinary Portland cement to 3 parts fine aggregate by volume, unless otherwise specified. Water shall be added to the mix to produce a suitable consistency for the intended use.

The ingredients for mortar shall be measured in proper gauge boxes and mixed on a clean boarded platform or in an approved mechanical batch mixer.

All mortar shall be used within 30 minutes of mixing and no reworking of mortar shall be permitted thereafter.

2.3.1.2 Execution of Works

Grouted stone pitching

Prior to construction, the surfaces against which the stone pitching is to be placed shall have been prepared and finished in accordance with the appropriate provisions of this Specification. Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of the Engineer before stone pitching is placed.

Construction of grouted stone pitching shall commence at the lowest part of each structure or section of a structure and continue progressively upward. Long structures such as drain linings and slope protection pavements shall be constructed in sections of practicable length.

The surface against which the work is to be placed shall be moistened with clean water a little in advance of construction, and covered with a layer of cement mortar about 50 mm thick. Stones shall be firmly set by hand into the mortar, densely packed against adjacent stones and built up to form a stone structure of more or less uniform thickness which shall nowhere be less than 15 cm (measured perpendicularly to the surface covered). All the while that stones are being placed all voids in the structure shall be packed solidly with mortar and stone spalls. However, the surfaces of stones in the exposed faces and edges shall not be covered with mortar. The exposed surfaces and edges of the structure shall be constructed such that they have as large a proportion as practicable composed of stone faces. Weep holes shall be provided as shown on the Drawings or as directed by the Engineer.

Mortar which has been mixed for more than 30 minutes shall not be used in the works. Nor shall mortar be laid against the supporting surface more than 2 minutes before pitching stone and building up the structure to full thickness is commenced on any section of the work, as the construction advances.

Wheeep holes shall be provided to allow water to drain from within the structure. If not
otherwise specified by the Engineer, at least one wheeep hole per m² shall be arranged by the Contractor.

**Ungrouted stone pitching (rip-rap)**

Prior to construction, the surfaces against which the stone pitching is to be placed shall have been prepared and finished in accordance with the appropriate provisions of this Specification. Notwithstanding any earlier approval of these finished surfaces, any damage to or deterioration of them shall be made good to the satisfaction of the Engineer before stone pitching is placed.

Where shown on the Drawings, ungrouted stone pitching (rip-rap) shall be hand set to provide maximum interlocking effect. The largest stones shall be used at the bottom.

The stones shall be well bedded on a minimum 10 cm layer of gravel or crushed stones aggregate as specified on the Drawings. The bedding shall be rammed to an even surface.

### **2.3.2 Masonry Works**

This work shall consist of the construction of all structures or parts of structures to be composed of stone masonry as shown on the Drawings or as directed by the Engineer. Besides others, these may include erosion protection at the discharge channel at the bottom outlet, foundations superstructures, canals, drains, etc.

The work shall be carried out in accordance with this Specification and to the lines, levels, grades and dimensions shown on the Drawings and/or as approved by the Engineer. The work shall be carried out and finished all to the satisfaction of the Engineer.

### **2.3.2.1 Material**

**Stones:**

Stones shall be hard, uniform in texture, locally the best available from the quarry or elsewhere as approved by the Engineer. Stones, which are not similar to the samples supplied, shall be rejected. No round stone shall be used unless broken. Stones shall be fairly regular in size and every stone shall be fitted to the adjacent stones. No stone shall be less than 15 cm in size. Face stones shall be comparatively larger and uniform in size and colour to given a good appearance, and breadth of face stones shall be greater than the height. Face stones should tail into wall to a sufficient depth to bound well. Stones shall be broken and faces of wall shall be truly in plumb. Corner stones or quoins should be a good stone and dressed correct to angle and lay as headers and stretches.

**Mud**

Mud (clay) shall be of approved quality, obtained from foundation cuttings or borrow pits at 2-23
least 1 m below NGL. It shall be free from gravel or other foreign bodies. The clay so brought up from cuttings shall be collected first and allowed to dry completely. Then, it shall be beaten down into smaller particles before being passed through a standard 20 gauge wire mesh to remove course material. The fine sieved portion shall then be collected in a pit of appropriate size before addition of water to produce a homogeneous mass. The mud shall be thoroughly kneaded according to local practice.

**Water**

Water shall be clean and free from deleterious matter such as oil, acid, alkali, salt and vegetable growth.

**Cement**

Portland cement conforming to standard specification EN 197-1: 2000 shall be used. Cement shall be stored in weatherproof sheds on dry platforms and protected from rain and moisture. Cement which has partially set shall not be used.

**Sand**

Sand shall have a fineness modulus between 2.1 and 2.5 (i.e. fine sand). Sand shall be clean and free from dirt, clay or other impurities. Clay or total impurities shall not be more than 5 % by weight.

**Mud mortar**

Mud mortar shall be made by thoroughly mixing clay with water. The ingredient clay shall be checked thoroughly for aggregate etc. and evenly mixed, care being taken not to add more water than is required.

**Cement mortar**

Cement mortar shall be of proportions of 1 : 4 (1 cement; 4 course sand). The ingredient shall be accurately gauged by measure and shall be well and evenly mixed together in a mechanical pan mixer, care being taken not to add more water than is required. No mortar that has begun to set shall be used. Not more than one bag of cement shall be mixed one time, which shall be consumed within half an hour of its mixing. The work shall be well watered for a fortnight.

### 2.3.2.2 Execution of Works

**Random rubble masonry (uncoursed)**

The stones shall be dressed rough to approximate shape and size before use. The maximum bushing for un-plastered faces for stones shall be limited to 25 mm. On the surface to be plastered this shall not exceed 10 mm so as to incorporate lime plastering.
thickness within a margin of 5 mm. Stones used on facing shall be to the possible extend equal in tenure. The gaps between the stones should be properly filled up by spalls. The gaps should not exceed 50 mm and never be left hollow. The joints should be well packed with mortar with a poker. In no case, water should be allowed to be poured into joints. Only mortar to the required consistency shall be permitted. Bond stones shall be provided to the full width of the wall or to the tailed length of such stones. Quoins and corner stones are to be provided properly dressed to angles. The length of quoins shall be to full wall width and size suitably selected to match the courses. Care should be taken to see that joints of adjacent coursed are not in one vertical line. The mortar joints shall not exceed 25 mm in any case. Mud mortar shall be used unless otherwise specified. The stones to be used in jambs, reveals, sills and other places of such nature should be properly selected and dressed. All the joints should be raked out to depth 15 mm to enable pointing or lime plastering or cement plastering.

Rubble masonry (coursed)

The stones shall be properly selected and each course shall be of same height. Stones should be semi-dressed at quarry and the final dressing shall be done at Site of work by chisel and hammer. The bushings shall not exceed 20 mm. Corner stones should be properly dressed to angles. The bond stones shall be spaced 1.5 m apart. The height of quoins should not exceed the height of the course. Vertical joints should be avoided. The joints should be raked out to a depth of 15 mm to enable pointing or lime plaster washing or cement plastering.

Ashlar masonry

The stones shall be hard, tough and durable from an approved quarry. Stones shall be chisel-dressed on all edges to have perfectly square or rectangular faces so that they may be laid in perfect horizontal and vertical joints. Minimum height of stones shall be 20 cm and breadth not less than 1.5 times height. Stones shall be laid alternate headers and stretchers with breadth joints in two consecutive layers. Each course shall be truly horizontal and each stone shall be laid on its natural bed. The wall shall be truly in plumb. No joint shall be thicker than 3.5 mm. Not more than 60 mm height of masonry shall be constructed at a time. Mud mortar shall be mixed thoroughly to get a uniform workable consistency. If cement mortar is used, it shall first have water added slowly and gradually and mixed thoroughly to get a uniform mortar of workable consistency. Fresh mortar shall be used. At the end of day’s work the masonry shall be flooded with 25 mm water at the upper surface in case of cement mortar. All stones shall be roughed before use. Usually, exposed faces of stones are rough chiselled.

Workmanship

General construction techniques shall be in accordance with the best local traditions. The Contractor shall ensure that only the most experienced of local masons are employed on random rubble works in foundation.
The selection of stone or blocks for foundation shall be convenient, placing them in position to obtain a good bond while restriction in cutting of the stones to removal of inconvenient corners only. The stones shall be laid on their natural beds as nearly as possible at right angles to the direction of the load or thrust.

Wetting of stones shall be necessary only in the case of very dry porous stones. Impervious stones do not have to be wetted before being laid. Water absorbing natures of the various stones shall first be ascertained on samples and as far as practicable only stones of approximately the same porosity shall be used throughout any length of walling.

Quoins shall be built up in advance of the main body of the wall to a height of 50 cm and adjacent wall on both sides stepped down. Quoins stones shall be more regular in shape than the main wall and shall be selected and set out on the ground before. They shall be carefully dressed to produce regular corners. The masonry shall be brought to courses at every 50 cm intervals. Method of wall construction shall be as per the best local traditions, using as far as possible stones that are broad on the bed and which tail-in well with adjacent stones. Void spaces shall be filled with hearting stones selected to bond in with the rest. Stones chips shall be used only to fill voids between hearting stones and to avoid use of excessive mortar. All stones shall be solidly and well bedded in mortar, all voids being packed with mortar. The random rubble wall shall be brought to courses at convenient heights but not exceeding 50 cm. The course height shall correspond with the quoin stones or their multiples, as necessary. At levels with changing width of footings, the projecting stones shall be headers with the long side tailing under the footing. Stones for face walling inside and outside has to be minimum dressed in order to receive evenly joints on all four sides.

Bonds shall be both transverse (across the thickness of the wall) and longitudinal. Transverse bonds shall be achieved by use of bond stones of lengths extending the full width of the wall. These shall be placed at approximately 60 cm. Vertical and horizontal intervals, staggering the stones between the two faces.

Joints in the wall shall be not less than 6 mm thick in to any part of the bed and shall be thick enough throughout to take up any irregularities of the stones without making a stone-too stone contact. Interior wall of 30 mm thickness shall have stones extending to the full thickness of the wall. It should be break joints with stones at least half the thickness of the wall.

At ground level, the wall shall be brought to course and the top finished off level with a thick layer of cement mortar (1 : 4) not less than 20 mm thick. In the case of sloping grounds, random rubble work shall be coursed and finished level as above at the lower. Levels at the corners of the top most courses shall be checked for uniformity before proceeding with further works.

Protective measures consisting of covering by sacking, tarpaulins or other material shall be taken during rains to prevent mortar being washed out of the joints before it has set.
Wheep holes shall be provided to allow water to drain from within the structure. If not otherwise specified by the Engineer, at least one wheep hole per m² shall be arranged by the Contractor.

2.3.3 Gabions and Mattresses

2.3.3.1 General

The position and dimensions of gabions and mattresses shall be as shown on the drawings. The gabions shall be of the case type, manufactured in the workshop or outside the place of erection. They shall have a rectangular prismatic shape with faces made of heavily zinc coated mild steel net framing, and shall be filled with cobbles or fragments of rock on the site where they are to be used.

2.3.3.2 Wire

Dimensions: the opening of the mesh “D”, i.e. the distance between the axes of the twists, and wire dimensions shall be as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>GABION</th>
<th>MATTRESSES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mesh opening “D” (mm)</td>
<td>60</td>
<td>80</td>
</tr>
<tr>
<td>Wire (mm)</td>
<td>2.7</td>
<td>2.7</td>
</tr>
<tr>
<td>Selvage wire (mm)</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

Tensile strength

The wire used for the manufacture of both gabions and mattresses and lacing, shall be conform to EN10244-2 with a tensile range of 540-770N/mm², steel grade 0.10% Carbon max, Weld sheer strength minimum 75% of the tensile strength of the wire.

Elongation

Determined by testing (before manufacture of the mesh) a sample at least 300 mm long, shall not be less than 12%.

Zinc coating and dimensional tolerance of the wire shall be as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>GABION</th>
<th>MATTRESSES</th>
</tr>
</thead>
</table>
The adhesion of the zinc coating to the wire shall be such that, when the wire is wrapped six turns around a mandrel having four times the diameter of the wire, it does not flake or crack when rubbing it with bare fingers.

The wire shall be PVC coated with an average coating thickness not less than 0.5 mm. The PVC coating shall be a compound UV stabilized material as per ISO4892-2.

### 2.3.3.3 Rockfill

Material for filling shall be composed of cobbles or rock fragments, dense, sound and resistant to abrasion, non-porous; it shall be free of cracks, seams, shale partings, conglomerate bands and other defects that would tend to increase unduly its susceptibility to destruction by erosive action.

The shape of the individual rock pieces shall be positively rounded; fragments having too flat a shape shall not be used as rockfill for gabions.

The individual cobbles or rock fragment shall be reasonably well graded with minimum size not less than dimension D of mesh and maximum size approximately 2.5 times D.

Bigger cobbles shall be acceptable, provided that their total volume does not exceed 5% of the total cell volume.

Gabions shall be overfilled by about 25 to 70 mm to account for future structural settlements.

A sample of the proposed fill material should be provided for approval by the Engineer prior to its use in the Works.

### 2.3.3.4 Installation

The gabions and mattresses shall be generally placed on horizontal or inclined surfaces, with their bottom and sides slightly embedded into the original ground. Excavation and trimming to regularize the foundation of gabions and mattresses shall be carried out where necessary, in conformity with the instructions issued by the Engineer.

The surface slope of buttress fill (protected by mattresses) shall be carefully flattened.

Depressions and protrusions of the finished surface shall not exceed 100 mm from the lines shown on the drawings.
2. Soil and Geology Specification

Geotextiles shall be placed between gabion/mattresses and foundations, as shown on drawings. The Geotextiles shall have a weight not less than as shown on the drawings expressed in gr/m².

Gabions and mattresses, already sewn in their box shape with diaphragm sections inserted and placed according to the outlines shown on the drawings, shall be linked by means of lacing wire, after which filling operations shall take place.

The gabions and mattresses which are gradually added shall be strongly sewn to those already in place. The various layers of gabions shall also be connected to each other. The connection shall be carried out between full gabions as well as between full and empty gabions. The filling material shall be introduced into each gabion by hand, placed so as to fill it completely and without compaction.

Once the filling operations are completed, the gabions shall be closed by dropping the lids and sewing all around their edges.

2.3.4 Drainage

2.3.4.1 General

This work shall consist of the construction of surface drains, subsoil drains, pipe culverts, box culverts, sumps and other drainage structures in accordance with this Specification or as directed by the Engineer. Drainage works shall be constructed to the lines, levels, grades and cross-sections shown on the Drawings or as directed by the Engineer.

2.3.4.2 Excavation and Backfilling for Drainage Works

Description

This work shall consist of excavation for the construction of surface drains, subsoil drains, cast in situ box culverts, and other drainage structures, and shall include furnishing, placing, compacting and shaping foundation bedding materials, backfilling excavations against completed structures with suitable material or granular backfill where specified, and the removal and disposal of all excess excavated material, in accordance with this Specification and as shown on the Drawings and as required by the Engineer.

Excavation Material

Material excavated shall be classified as common excavation covering both soft material and rock.

- Granular Bedding Material
Granular bedding material for the foundations of structures shall be suitably graded broken rubble, crushed stone, crushed gravel, sand or other material as specified on the Drawings or as required by the Engineer.

• Concrete Bedding

Concrete bedding or blinding for the foundations of structures shall conform to the requirements of Chapter 6 of this Specification for the class of concrete specified on the Drawings or required by the Engineer.

• Ordinary Backfill Material

Ordinary backfill material shall be suitable material as defined in Chapter 3 of this Specification. The maximum particle size of the backfill material shall be 50 mm.

• Granular Backfill Material

Granular backfill material shall be sand, crushed stone, crushed gravel or a mixture of crushed and natural aggregates, shall be essentially free from vegetation and other organic matter and clay, and shall not contain lateritic or concretionary materials.

The material shall conform to the following physical and mechanical quality requirements:

• The fines shall be non-plastic;

<table>
<thead>
<tr>
<th>Table 2.3-3  Grading Limits for Sand Backfill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size</td>
</tr>
<tr>
<td>------------</td>
</tr>
<tr>
<td>10.0 mm</td>
</tr>
<tr>
<td>5.0 mm</td>
</tr>
<tr>
<td>1.18 mm</td>
</tr>
<tr>
<td>300 μm</td>
</tr>
<tr>
<td>150 μm</td>
</tr>
</tbody>
</table>

• Material other than sand shall have a gradation conforming to one of the envelopes shown in Table 2.3-4
Table 2.3-4  Sieve Size

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% Passing by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>100</td>
</tr>
<tr>
<td>28.0 mm</td>
<td>70 - 100</td>
</tr>
<tr>
<td>20.0 mm</td>
<td>60 - 90</td>
</tr>
<tr>
<td>10.0 mm</td>
<td>45 - 75</td>
</tr>
<tr>
<td>5.0 mm</td>
<td>30 - 60</td>
</tr>
<tr>
<td>2.0 mm</td>
<td>20 - 50</td>
</tr>
<tr>
<td>425 μm</td>
<td>10 - 30</td>
</tr>
<tr>
<td>75 μm</td>
<td>0 - 2</td>
</tr>
</tbody>
</table>

- Concrete Backfill
  Concrete backfill where specified shall be of the grade as shown on the Drawings and shall conform to Chapter 6 of this Specification.

Excavation

The Contractor shall notify the Engineer sufficiently in advance of the beginning of any excavation so that cross-section elevation and measurements may be taken of the undisturbed ground. The natural ground adjacent to the structure shall not be disturbed without permission of the Engineer.

Trenches and foundation pits for structures and structure footings shall be excavated to the lines, grades and elevations shown on the Drawings or as directed by the Engineer. Excavations must be kept free from water and temporary drains, sumps and pumps shall be provided when necessary. The rate of excavation and backfill shall be approved by the Engineer.

Boulders, logs and other objectionable materials encountered in excavation shall be removed.

After each excavation is completed the Contractor shall notify the Engineer to that effect and no footing, bedding material or structure shall be placed until the Engineer has approved the depth of excavation and the character of the foundation material.

Rock and other hard foundation material shall be cleared of all loose material and cut to a firm surface, either level or stepped or serrated, as specified or shown on the Drawings or directed by the Engineer. All seams and crevices shall be cleared out and grouted with Portland cement grout at the time the footing is placed.

All loose and disintegrated rock and thin strata shall be removed. When the footing is to rest
on material other than rock, special care shall be taken not to disturb the bottom of the excavation, and excavation to final grade shall be deferred until just before the footing is to be placed. When, in the opinion of the Engineer, the foundation material is soft or mucky or otherwise unsuitable, the Contractor shall remove the unsuitable material and insert foundation fill material or concrete as specified or shown on the Drawings or directed by the Engineer. If foundation fill material is required it shall be placed and compacted in layers not more than 150 mm thick or as directed by the Engineer. The degree of compaction shall be equivalent to that of the surrounding foundations.

All excavation surfaces and surfaces of backfill material against which concrete is to be placed shall be even and firm and true to line and level.

All excavated material, so far as suitable, shall be utilized as backfill or embankment. The surplus material, whether or not temporarily allowed to be placed within a stream area, shall be finally disposed of in such a manner as not to obstruct the stream nor otherwise impair the efficiency or appearance of the works, nor is it to endanger the partly finished structure.

Excavated material suitable for use as backfill may be deposited by the Contractor in storage piles at points convenient for rehandling of the material during the backfilling operation.

Excavated material shall be deposited in such places and in such a manner as not to cause damage to roads, services or property either within or outside the Works reserve, and so as to cause no impediment to the drainage of the Site or surrounding area.

**Backfilling with Ordinary or Granular Backfill Material**

All spaces excavated under this Specification and not occupied by a permanent structure shall be backfilled. Backfill material shall be free from large lumps, wood and other extraneous material.

Backfill not within the embankment areas shall be placed in layers not more than 250 mm in depth (compacted measurement) and shall be compacted to a density comparable with the adjacent undisturbed material.

Backfill within the embankment areas shall be made with approved material placed in uniform layers not to exceed 150 mm in depth (compacted measurement) and each layer shall be constructed in accordance with Chapter 3 of this Specification except that mechanical tampers may be used for compaction. Each layer of backfill shall be wetted uniformly as necessary and compacted to the same requirements as the adjacent earthwork as specified in Chapter 3 of this Specification. Unless otherwise approved by the Engineer, hand tamping will not be accepted.

In placing backfill and embankment, the material shall be placed insofar as possible to approximately the same height on both sides of the structure. If conditions require backfilling appreciably higher on one side, the additional material on the higher side shall not be placed
until permission is given by the Engineer or until the Engineer is satisfied that the structure has enough strength to withstand any pressure created.

No backfilling shall be placed against any structure until the Engineer has given permission. Jetting of fill or other hydraulic methods involving, or likely to involve, liquid or semi-liquid pressure shall be prohibited.

Special care shall be taken to prevent any unduly high pressures against the structures.

The placing of embankment and the benching of slopes shall continue in such a manner that at all times there will be a horizontal berm of thoroughly compacted material for a distance at least equal to the height of the abutment or wall to be backfilled.

2.4 Road Construction

The general requirements (principles of road construction works) - as described in the following Sections of the General Technical Specifications - shall be applied and shall be valid for all road construction works to be performed under the Contract, such as rehabilitation / improvement of access roads, construction of operational roads on the dam crest and berm as well as roads in the irrigation system.

For particular requirements of single structures / roads, such as pavement design, material specification, compaction requirements, etc. it is referred to the Particular Technical Specifications and/or the Drawings.

2.4.1 Permanent Roads

The Contractor shall construct roads respectively rehabilitate and improve existing roads to the Permanent Works following the route shown on the Drawings and/or as ordered by the Engineer.

The Contractor shall excavate cuttings and form embankments in accordance with the Drawings and the instructions of the Engineer. In case of road rehabilitation / improvement works, the Contractor shall grade the existing carriage ways to dimensions and profiles in accordance with the Drawings and the instructions of the Engineer.

The Contractor shall be responsible for the execution of the earthworks in such manner that the finished requirements and dimensions are obtained. The Contractor shall carry out the work such that excessive drying and cracking of earthworks and subgrade is prevented.

For the purposes of road construction the following definitions shall apply:

- “formation” shall mean the surface of cut or fill material prepared to receive the sub-base, if required, or the course base
• “formation level” shall mean the required level at any point on the formation
• “subgrade” shall mean the zone immediately below the formation
• “sub-base” shall mean the material placed immediately over the formation (if required)
• “base course” shall mean the material placed over the formation or over the sub-base
• “road-base” shall mean the top surfacing course of the gravel road

2.4.1.1 Fill and Subgrade

Fill for roads (respectively fill for potholes and depressions in case of road rehabilitation / improvement works) shall be approved material obtained if possible from excavations on the Site. It shall be free from rubbish, vegetation, roots, topsoil or other organic material.

Where excavated material is unsuitable or insufficient to form fill for site roads, the Contractor shall import material from a Site approved by the Engineer.

Fill material shall be placed in successive horizontal layers not exceeding 20 cm in thickness (before compaction). The Contractor shall compact each layer to reach a degree of compaction of Dpr ≥ 95 % (modified proctor).

The formation level, whether in cut or fill, shall be compacted to the minimum extent necessary to achieve a compaction degree of Dpr ≥ 95 % (modified proctor) on the following base course layer. Where this is not practicable, sub-base material of 15 cm minimum thickness shall be spread and compacted as directed by the Engineer.

The Contractor shall programme his work such that subgrade preparation (including sub-base) and base course placement follow each other in close sequence. If the subgrade is not covered immediately by base course and as a result deteriorates or suffers damage due to traffic or any other cause, then the Contractor shall make good the subgrade at his own expense by re-compacting or re-constructing as the case may require.

The material used for sub-base shall be naturally occurring gravel or crushed rock of uniform grading capable of being compacted to achieve a well-knit dense layer. Stones larger than 100 mm shall be removed.

Sub-base material shall be spread evenly in layers of not more than 15 cm compacted thickness and compacted to obtain a well-bound surface finish, any loose or segregated areas being made good by the addition of fines or by removing and replacing with fresh materials as directed by the Engineer.

Compaction shall be carried out by approved plant operating on the material until a degree of compaction of Dpr ≥ 95 % (modified proctor) is obtained.
2.4.1.2 Base Course

The base course shall comprise 15 cm thickness of approved material rolled to a compacted thickness with a minimum of 6 passes of an 8 t vibrating roller.

The base course material shall be suitably proportioned to conform with the requirements of the Particular Technical Specifications or such other grading as approved by the Engineer.

2.4.1.3 Road-base (Gravel - sand Pavement)

The road-base shall comprise at least a 15 cm average thickness of approved sand - gravel rolled to a smooth even surface, true to crossfalls line and level.

The term “sand - gravel” shall be any such material which might be specified for use as a road-base, e.g. some forms of partly decomposed rock, soft rocks, spalls, clayey sand and crushed rock.

The road-base will be a top surfacing course made from one or from a combination, of these materials and will be applied to the road formations. If not otherwise specified, the grading of the road-base material shall be such that there is a minimum 15 % by weight passing the 0.075 mm sieve.

Where permanent access roads are used by the Contractor for access during construction, the Contractor shall reinstate to the satisfaction of the Engineer the road-base to the thickness, grade and crossfall specified.

Laying and compacting of the road-base:

Road-base material shall be spread in a uniform layer across the full width required, pulverized so that the maximum size of any particle is not greater than one half the compacted thickness of the layer. It shall then be mixed, watered if directed by the Engineer, graded and compacted by at least 6 complete passes of a 10 t smooth drum roller or other equivalent and graded to final level.

The compacted thickness of any layer shall not exceed 15 cm and where a greater compacted thickness is required the material shall be laid and processed in two or more layers.

2.4.1.4 Tolerances for Road-base

The tolerances on level permitted in the final surface of the road-base will be:
Table 2.4-1 Tolerances on Level Permitted in the Final Surface of the Road-base

<table>
<thead>
<tr>
<th>Road-base</th>
<th>Thickness</th>
<th>3m straight edge</th>
<th>Camber</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variation permitted</td>
<td>25 mm</td>
<td>25 mm</td>
<td>25 mm</td>
</tr>
</tbody>
</table>

The average thickness of the road-base measured at seven points over a length of 100 m shall be at least equal to the thickness specified or ordered.

The final average width of the road-base, measured at seven points over a length of 100 m shall be at least equal to the width specified or ordered and at no point shall the distance between the edge of the road-base and the centerline of the road be less than specified or ordered by more than 100 mm.

Footpaths shall be constructed with a 15 cm average compacted thickness of road-base as specified above.

### 2.4.2 Temporary Access Roads

The Contractor shall assess his own need for access roads to the temporary site installations and to storage areas, temporary offices, quarries, borrow areas / pits, excavations and spoil tips and shall construct such roads at his own expense.

### 2.5 Grouting

#### 2.5.1 Plant and Equipment

##### 2.5.1.1 Supply of Plant

The Contractor shall supply all the requisite plant and piping which are necessary for drilling, testing and grouting of the holes at all stages.

All required connections for water supply are included. The supply and the unit costs are including all auxiliary materials and energy required for the grouting works.

##### 2.5.1.2 Drilling Equipment

Water pressure test control holes shall be drilled with standard rotary drills and core drilling equipment using triple-tube core barrels with bottom discharge bits. The rig shall be capable of drilling vertical and inclined boreholes in rock of a diameter not less than 62 mm. Where core recovery is required, the minimum core diameter shall also be 62 mm.

Grout holes shall be drilled with rotary-percussive drills with bits, but up to 10 % of the grout
holes quantity may be ordered by the Engineer to be drilled by core drilling methods. In granular materials percussive drills may be used. The drilling rig must be capable of drilling vertical and inclined boreholes in rock of a diameter not less than 62 mm to the depths shown on the Drawings and shall be equipped to provide a continuous water flush of not less than 15 l/min issuing from the drill bit.

The use of grease or other lubricants on the drill rods or in the grout holes will not be permitted but an approved neutral liquid soap may be added to the drill water.

2.5.1.3 Packers:

The packers required for water pressure testing or for grouting, should be capable of sealing the hole against the maximum pressure envisaged during grouting. The Contractor shall be responsible for providing packers suited to the ground conditions and the type of drilling and injection equipment, which he proposes to use.

The packers must be dimensioned with regard of a dam height of 30 m, a maximum grouting depth of 20 m and a grouting pressure of maximum 10 bar.

2.5.1.4 Water Testing Equipment

Water testing equipment shall include pumps fitted if necessary with air bottles or other methods of ensuring steady pressure and capable of delivery of 100 l/min at 1 Mpa. The equipment shall also include all necessary tanks, gauges, water meters, hoses and pipes. The Contractor shall ensure that leaks do not occur in hoses, pipes and connections during the water pressure tests.

2.5.1.5 Injection Equipment

Grout pumps shall be of variable pressure ram type and with continuous supply of grout/grout mix or other approved type of pumping equipment. The type of grout pump shall ensure that the pumping equipment is capable of continuous delivery of grouts up to the maximum pressures required. A standby pump shall be supplied as part of the grouting plant. In no circumstances shall grouting equipment relying on the direct application of air pressure be used for injection. Each pump shall be provided with two mixing tanks of about 500 litres capacity, each tank having a mechanical mixer and arranged so that grout is mixed effectively in the first tank using a high speed impeller type mixer (minimum speed 1500 rpm) and delivered through a screen to the second or agitator tank. The suctions of the grout pump shall be connected only to the delivery from the second tank. The mixer shall be provided with a rate of 20 liters per minute to an accuracy of one tenth of a litre, for controlling the amount of mixing water used in the grout.
Should it be necessary to incorporate sand, silt or other inert filler in the grout in proportions greater than one part filler to one part cementitious material, the grout shall be mixed in a high speed colloidal unit capable of producing a highly intimate mixture of main and subsidiary aggregate.

Where clay or bentonite are added to the grout suspension, separate mixing tanks must be provided in which the clay-water mix can be prepared and kept agitated until required.

The employed piping system for the grouting works will be of continuous circulation type. Holes shall be injected by direct connection to the grouting plant. The manifold at the top of the grout pipe shall be provided with a pressure gauge, a relief valve and a valve enabling the delivery from the pump to be cut-off from the hole. A return grout line, equipped with a pressure relief valve set to the required pressure shall be connected to the manifold as a precaution against the application of excessive pressures which might cause uplift and to allow continuous circulation of the grout. The return line shall be led back to the agitator tank. An accurately indicating pressure gauge shall also be provided at the grout pump (accuracy of pressure gauge 5 %).

2.5.2 Materials

2.5.2.1 Grout Mixes

Except where otherwise approved by the Engineer the rock grouting will be performed with a mixture of cementitious material and water.

The water / cement ratio will normally be in the range 3 : 1 to 0.6 : 1 by weight. Where grout consumption is large the use of sand or other inert filler in the basic grout may be approved by the Engineer.

The Contractor shall make tests with the materials available and submit proposals for grout mixes for the approval of the Engineer. Bentonite clays may be added to the grout to minimize bleed. The volume of bentonite used shall generally be 2 % to 4 % of the weight of cement used in the mix and shall be as approved by the Engineer. Maximum bleeding of proposed mixes should not exceed 5 % and the results on Marsh cone tests should be between 28 sec and 36 sec.

2.5.2.2 Water

Water used for pressure testing and for mixing grout shall comply with the specifications applied for concreting works.
2.5.2.3 Cement

The cement used for the grout mix shall be use Portland cement and in addition shall have a minimum specific surface of 3000 cm$^2$/g.

Controlled fineness cement will comply with BS12 with maximum particle size of 45 microns and will have a specific surface controlled within a range determined by the Engineer. The fineness of the cement powder shall be not less than 8000 cm$^2$/g. The Contractor shall submit details with the information required under the specification for “Grout Mixes” of the controlled fineness cement, which the Contractor intends to use for his grouting works - if so instructed by the Engineer.

2.5.2.4 Bentonite:

Bentonite shall be delivered from an approved source and with approved quality parameter. The Contractor shall obtain a certificate from the supplier of the bentonite, stating from which manufacturer's consignment the bentonite material, delivered to Site, has been taken and showing properties of the consignment and date of production. The certificate shall indicate the type, the moisture content and the liquidity limit of bentonite provided. The liquidity limit must have a mean value bigger than 350 %, for every 3 tests. This certificate shall be made available to the Engineer on request.

2.5.3 Probe Hole

Most of drilling works shall be conducted on the cap concrete shown on the Drawings. In the case of no cap concrete on the Drawings, The Contractor shall find or prepare the suitable method for drilling such as casing method or pre-backfilling method depend on geological condition.

2.5.3.1 Requirement for Drilling

The Contractor shall perform the following probe drilling operations on the locations shown on the Drawings of directed by the Engineer:

- Drilling for both curtain and blanket grouting of the foundation under the dam embankment;
- Drilling for drainage holes for Spillway Crest Structure;
- Drilling for curtain grouting in the Diversion Conduit;
- Drilling for curtain grouting in the leakage collection wall;
- Drilling for foundation drainage holes;
• Drilling for curtain grouting in the check dam;

During the course of the work, the Engineer may direct the Contractor to perform core drilling vertically or inclined holes in accordance with Clause 2.6.3.2. Such cored holes shall, where directed by the Engineer, be water tested in stages as the drilling progresses in accordance with Clause 2.6.3.3.

2.5.3.2 Location and Method

The location, direction and length of holes and their reference numbers will be as shown on the Drawings or as determined by the Engineer, who may at any time increase or decrease the number of holes or instruct drilling to a greater or lesser depth. The order and timing in which holes are drilled shall be as instructed or approved by the Engineer.

If foundation conditions and rock conditions as revealed by the excavation, drilling, testing and grouting operations, indicate that grouting at greater depth, or closer spacing, or in other locations than those shown on the Drawings is necessary, the Contractor shall drill holes to such depths and spacing as directed by the Engineer.

Grout, test, exploratory and instrumentation holes may be drilled with either rotary type diamond drills or percussion type drills, provided that where holes satisfactory for subsequent grouting cannot be drilled by percussion type drills, rotary type diamond drills shall be used.

The diameters specified shall be obtained at the maximum depth required. The equipment shall be capable of drilling hole to a maximum of 100 m depth. The drilling equipment shall be capable of drilling at any angle and be capable of being set to an accuracy of one degree.

Holes shall be drilled to an accuracy of 3° of angle of that specified but the Engineer may require certain holes to be drilled within 2° of the specified direction. Holes shall be drilled from positions shown on the Drawings with a tolerance of 250 mm. Holes for testing and grouting shall have diameters not less than 35 mm. For percussion drill holes the bit diameter shall be at least 8 mm greater than that of the coupling used for drill rods.

All holes shall be drilled without mud-support and without the use of grease, ‘rod-dope’ or other non water soluble material or the lubrication of the drill rods. The Engineer may permit the use of an additive in the drilling water. A sample of the additive shall be submitted to the Engineer for approval at least 7 days prior to its being used. The concentration of the approved additive shall not exceed the manufacturer’s recommendation.

Unless otherwise directed by the Engineer all holes shall, immediately after drilling, be thoroughly washed out with water, or air and water, under pressure from the bottom. Flushing shall continue until the waste eater runs clear.
2.5.3.3 Record and Core Box Treatment

Within 24 hours of completion drilling of a bored hole, the Contractor shall submit in duplicate a complete log of the hole in a form approved by the Engineer. The log shall include the following data:

- Location;
- Borehole number;
- Type and diameter of boring;
- Ground level;
- Immediate, intermediate and equilibrium water levels with times and dates. Note on colour and losses, etc.
- Description and state of weathering of rock and the levels of its boundaries;
- Percentage core recovery;
- Fracture log;
- The results and levels of all in-situ testing;
- A record of the driller’s observations on progress of boring, rate of penetration, type of bit and speed of rotation of bit;
- Water pressure test results.
- The logging of rock cores shall be based upon the Geological Society Engineering Group Working Party Report ‘The Logging of Rock Cores for Engineering Purposes’
- Preferably, cores should be logged by the same approved person to avoid discrepancies in description of rock. The fact that the Engineer may be present and keeping a record of the drilling shall not relieve the Contractor from the requirement for keeping an accurate log as described in this sub-clause unless specifically approved, in writing, by the Engineer.

The Contractor shall provide strong long core boxes to the approval of the Engineer. Each box shall hold cores from 5 m of hole and they shall be provided with fasten-able lids.

The Contractor shall place the core in the box in the correct sequence after extraction from the core barrel. The core at the bottom of each lift shall be marked immediately it has been placed in the box and a corresponding mark shall be printed on the side of the core box and on the rock core. When core is not recovered, timber blocks of square cross-section shall be placed in the box by the Contractor. These timber blocks shall be cut to the same length as the core losses and placed in the positions for which the core was lost. If these positions cannot be determined, the blocks shall be placed at the top of the lift. A box shall not contain
cores from more than one hole. Designating marks, hole numbers and elevations shall be placed on the boxes and along the line of cores as directed by the Engineer. The covers shall be fastened securely to the core boxes, and the boxes shall be delivered to the Engineer at a point designated by the Engineer, in the vicinity of the Works.

Where directed by the Engineer, the cored holes shall be grouted.

2.5.4 Grouting Hole Preparation

2.5.4.1 Location of Grouting

The positions, depths and inclinations of all grout holes will be as directed by the Engineer and as shown on the Drawings. Depending on the results of water pressure tests performed after grouting is implemented, the Engineer may order the drilling and grouting of additional grout holes.

2.5.4.2 Drilling Grouting Holes

The items in the Bill of Quantities for drilling grout holes in foundations in the stage between depths of 0 m to 5 m; in the stage between depths of 5 m to 10 m; and in the stage between depths of 10 m to 15 m; and in the stage between depths of 15 m to 20 m; include all drilling in the foundations of the dam embankment and spillway and elsewhere as shown on the Drawings or as directed by the Engineer.

The sequence of grout holes shall be:

- Primary holes will be drilled and grouted first, to the depths shown on the Drawings. Specific primary holes, as shown on the Drawings shall be with continuous core sampling and shall be water tested before grouting.

- Secondary holes will be drilled and grouted. The depth of the secondary holes shall be as shown in drawings.

- Control holes will be drilled with a 40° inclination and grouted unless otherwise directed by the Engineer. The depth will be as directed by the Engineer. Control holes shall be water tasted before grouting.

- Tertiary holes will be drilled if secondary holes have exhibited significant grout takes (50kg cement per meter) and control holes indicate they are necessary. The minimum depth will be 15 m or as directed by the Engineer. Every 5th tertiary hole shall be water tested before grouting.
2.5.4.3 Washing and Cleaning

At the completion of the drilling of any stage and before grouting is commenced, the drilling water shall be allowed to run until the return from the hole is clean. The quantity of water flowing into the hole during this washing period shall not be less than 15 l/min. If necessary, air and water under pressure shall be used to remove erodible material.

Should connections take place to adjacent holes, the washing shall be continued until the flow of water from the hole to which the connection was made is clear.

2.5.5 Water Pressure Test

A water pressure test shall be carried out where directed by the Engineer in grout holes prior to grouting, in cored and test holes and elsewhere as required by the Engineer.

Water pressure tests shall be carried out in stages of depth not exceeding 5 m, unless otherwise approved by the Engineer, with clean water and the rate of flow shall be determined to an accuracy of 10 per cent for flows exceeding 1 litre/min, using an air vessel to smooth out fluctuations of pressure. The results shall be expressed in Lugeon unit 1. Lugeon unit is determined by a water pressure test were a leakage occurs of 1 litre of water per minute per meter length of hole under pressure of 1MPa.

The multiple pressure test consists of a series of simple water pressure tests performed in an unbroken sequence on the same stage at varying pressures, usually in the ratio 1:2:3:2:1 where 3 represents the maximum safe pressure for the stage measured at the top of the borehole as indicated by trial injections. In the absence of trial injections the maximum safe pressure measured at the top of the borehole shall be taken as equal to 0.01 MPa multiplied by the depth to the top of the stage in meters.

The water pressure test shall be carried out between a packer and the bottom of the hole or between packers in depth stages to suit the variation of jointing of rock.

Washing incidental to, and concurrent with, the drilling operation is not sufficient to adequately clean the hole prior to water testing and grouting. Other flushing measures must be employed to clearly defined measures of acceptability. Such work must be measured (e.g., per pump hour) and paid for, at pre-agreed unit rates. The purpose of this flushing or washing is to clear the entrance into fractures for water or grout. Removal of substantial clay infilling by washing is not possible and should not be the goal of a hole washing operation.

Water pressure testing of the multipressure ““Houlsby”” type should be specified for all stages in Exploratory holes, Superprimaries, and Verification holes. This may not be necessary if optical televiewers are deployed in these holes to provide information on the rock fissure aperture size, joint frequency, and the absences or existence of weathered materials or joint infilling. Despite the universal use of stable, High Mobility Grouts (HMG”s)
in contemporary practice (e.g., Bruce, Dreese and Heenan 2010) the tendency to eliminate the simple single-stage test on all (or most) other stages should be resisted in the Specifications or in the field. The authors feel that every stage should be water-pressure tested, in some fashion, as this is an invaluable contribution to quantifying the progress of a rock grouting program. To not do so is a disservice to the project and a false economy. With modern header systems or "grout carts" and computer monitoring systems, water testing can generally be completed in less than 10 minutes per stage.

Further, the target residual permeability of the program must be clearly specified, as this is the essence of a Quantitatively Engineered Grout Curtain (Wilson and Dreese, 2003). Further, this actual Lugeon value must be clearly differentiated from the Apparent Lugeon value, which is calculated during the grouting of any single stage, and is a grout refusal criterion, not a rock mass residual permeability.

In case of the foundation laid on the residual soil and weathered rock condition, The Contractor can change the constant head injection method instead of the Lugeon test.

### 2.5.6 Injection Sequence and Maximum Injection Pressure

A pattern of grout holes is envisaged under the core of the dam embankment and under the concrete construction.

Should the grout hole spacing shown on the Drawings not be sufficient to seal the rock to the satisfaction of the Engineer, he may order additional holes to be drilled and grouted at closer spacing or centered on regions of more severe fracturing exposed by investigation. Similarly the Engineer may order that the depth of the grouting be increased and that grouting procedures be implemented on other parts of the dam.

Grouting shall be carried out in upward stages unless instructed otherwise. Each stage will generally be 5 m in length. The position, length and inclination shall be as shown on the Drawings unless otherwise directed by the Engineer.

The holes will be drilled to the full depth and will be flushed out and grouted in upwards stages. Each stage will be grouted using a single packer. A minimum of 6 hours will be allowed between stages for the initial setting of the grout. During this time the packer will remain in place for as long as back pressure is recorded or as directed by the Engineer.

No pressure grouting will be allowed within 10 m from a grouted hole unless 24 hours have elapsed from the completion of grouting.

Water testing in grout holes will be carried out using a single packer in downward stages during drilling. If directed by the Engineer water testing with double packers will be carried out in a fully drilled hole.

The grouting pressure will be the maximum that do not cause hydraulic fracture and/or up-lift.
in the rock mass. Unless otherwise directed by the Engineer, maximum injection pressure should be applied following table depend on the ground condition.

**Table 2.5-1 Maximum Grouting Pressure for Muvumba Dam**

<table>
<thead>
<tr>
<th>Hole depth (m)</th>
<th>Maximum injection pressure (kgf/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Curtain</td>
</tr>
<tr>
<td></td>
<td>Residual soil &amp; Weathered rock</td>
</tr>
<tr>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>1.0</td>
</tr>
<tr>
<td>15</td>
<td>1.5</td>
</tr>
<tr>
<td>20</td>
<td>2.0</td>
</tr>
</tbody>
</table>

Additional holes may be ordered, where it is considered that the initial grouting pattern has not rendered the foundations sufficiently watertight.

**2.5.7 Injection Procedure**

Where grout holes are above the water table, these shall be saturated with water over a period of 30 minutes (with sustained pressure to be determined on site) directly in advance of the grouting.

**2.5.7.1 Starting Mixture Ratio**

The choice of the starting mix may depend on one or more of a variety of factors: concept of the groutable openings in the rock, time since drilling, pressure testing or pressure washing, position of water table relative to the zone to be grouted, and experience with grouting similar rocks.

If the zone is below the water table, if the groutable openings have recently been wetted, if an appreciable part (but not all) the drill water was lost, or if the water take in the pressure test was at the rate of about 1 cfm, a starting mix of 3:1 (3 parts water to 1 part cement, by weight) grout might be the choice. If the foundation is believed to be dry, or a pressure test result of less than 0.5 cfm has been obtained, it is likely that a 5:1 or thinner grout would be selected for starting the hole. If all the drill water was lost and the drill rods dropped an observable amount, and if the point of the water loss is below the water table or the rock is still wet from pressure testing or pressure washing, the starting mix could be a 2:1 grout.

If the pumping rate does not decrease and/or pressure does not increase after the injection of 40 ℓ /m the grout is thickened to 2:1 by weight. Similarly, if the pumping rate does not
decrease and/or pressure does not increase after the injection of 40 lt/m the grout is thickened to 1:1 by weight. Holes, which are known to have intersected cavities or large fissures, shall be started on a thin mix but this may be thickened more rapidly.

If the hole accepts a few batches of the starting mix readily without pressure buildup, thicker mixes should be considered in accordance with the objectives of the grouting program.

In a relatively tight hole with the pressure quickly reaching the maximum allowable, the starting mix, if properly selected, should be continued until grouting is complete.

If the pressure starts to rise during an injection the grout shall not be thickened further but the injection continued on the mix in use until the pressure approaches the final pressure for the stage.

2.5.7.2 Mix Adjustment for Portland-cement Grout

Once the grouting of a stage has been commenced it shall be continued without interruption until completion. The stage can be considered as being complete, when the absorption of grout at the required pressure is less than 2 l/m/min averaged over a period of 10 minutes. However, where the grout hole continues to take a large amount of grout (about 200 l/m of hole or 50 kg cement per meter), even after the mix has been thickened, the Engineer may order the pumping to be done intermittently allowing up to 8 hours between pumping periods to allow grout in the foundation to set.

In case it is necessary to interrupt an injection before it is complete (e.g. there is a plant breakdown) about 500 litres of clean water shall be run into the hole before it is allowed to stand.

Should any hole couple to another during injection, the grout shall be allowed to escape from the coupled hole until it is of the same consistency as that being injected; the coupled hole shall then be capped and the combined holes brought up to pressure.

2.5.7.3 Treatment of Leak

Grout sometimes follows interconnected natural openings in rock to break out many tens of meter from the point of injection. Frequent and periodic checks of the area in the vicinity of the grout hole should be made during grouting operations. The Contractor should observe all known wells, springs, or seeps for unusual discoloration or increase in flow. The area patrolled should be enlarged as the grout consumption increases.

In the event that a leak occurs, The Contractor should estimate whether it represents essentially all the intake of the grout hole or only a small part of the total. If all the grout seems to be venting, the pressure should be reduced, the mix thickened, if not already thick,
and a small dike built to pond thick grout over the leak if possible; then the grouting should be stopped. The pond of grout will act as a reservoir to keep the vent full until the grout sets. If only a portion of the injected grout is venting, it may be worthwhile to expend considerable effort to save the hole. If the leak is in loose material, the procedure outlined above may be used, except that pumping should not be stopped but slowed to give the thick grout in the pond time to set. An accelerant may be added to the ponded grout. Sand is a good material to create a pond, since excess water in the grout can escape through it.

If the leak is in relatively sound rock, it may be talked with oakum, wicking, burlap, wood wedges, or lead wool. Burlap is particularly good if the grout contains much excess water, since it can seep through the burlap leaving the cement to build up in the fracture. If the grout is not too thick, brief delays may be tried but without prior injection of water. After the leaking has stopped, normal operations may be gradually resumed. If the leaking cannot be completely stopped and represents only a small part of the grout injected, grouting can be continued at a reduced pressure.

After satisfactory tests on completion of grouting in an area, all grout holes and water pressure test control holes shall be filled with thick grout from the bottom of the hole upwards so as to ensure that no significant voids exist.

**2.5.8 Completion of Grouting**

Grouting may be continued to absolute refusal at the maximum grouting pressure, although this is not usually done. There are two methods that are most frequently used to determine when grouting is complete. One specifies that grouting shall continue until the hole takes no grout at three fourths of the maximum grouting pressure. The other requires that grouting continue until the hole takes grout at the rate of 2 liter/min or less in 10 min measured over at least a 5-min period. This is often modified according to the mix and/or pressure used. The second specification is more readily correlated with pressure-test results than the first.

If there is doubt about the completeness of treatment in any zone or area, a check hole or holes should be drilled. Such holes can be drilled to recover core for examination, or they may be drilled for study by the borehole camera or television camera. However, a quicker and less expensive check can be made by drilling and pressure testing another grout hole. If tight when pressure-tested with water, the foundation is satisfactorily grouted; if the hole takes water, additional grouting is indicated.

**2.5.9 Grouting Records**

The Contractor shall keep a record and submit reports in duplicate to the Engineer on each
hole drilled showing the position, depth, inclination and direction of the hole as actually drilled, the nature and depth of all strata penetrated and the levels of any water encountered, the rates of drilling and of injection and the amount, consistency and maximum pressure of the grout injected at each stage. All holes shall be numbered to an approved system.

The record sheet shall be agreed with the Engineer. The Contractor shall forward the record protocols at the end of each working day.

2.6 Dam Embankment

A zoned earth-fill dam with central clay core shall be constructed. The dam embankment consists of compacted shell zones, a core zone and filter zones. The upstream slope shall be protected by rip-rap and the downstream slope by grass.

The embankment shall be constructed to conform to the finished levels shown on the Drawings.

During construction, the difference in levels at any two points on the unfinished surface of the embankment shall not at any time exceed 2 m. The difference in (temporary) levels shall not exceed 1 m at the contact zone between core and shell material. Temporary slopes shall not be steeper than 1 : 1.

The Contractor shall provide and maintain proper profile rails showing the position and inclination of the various slopes.

2.6.1 Core Trench

2.6.2.1 Scope

The core trench shall connect the dam core with the sound rock foundation. The depth of the trench varies between 2 m to 7.5 m depending to the actual depth of the bedrock level as shown on the Drawings (NMK20/002).

The width at the trench bottom shall be not less than 6 m. The sides of core trench shall be inclined approximately 1 : 1, but not steeper than 1.5 : 1 (V : H).

At locations where the actual bedrock level is deep, the core trench has to be widened at the top, i.e. jut out beyond the outer edge of the dam core. In this case, it has to be ensured that the overhanging section of the core trench has an outwardly orientated inclination of > 1 % as shown on the Drawings.
2.6.2.2 Execution of Works

Excavation shall be done down to sound or at least semi-weathered rock as approved by the Engineer. Weathered rock formations shall be excavated completely and properly. Care shall be taken that sandy and silty layers, old river courses, ox bows, etc. are intercepted by the core trench.

Excavation shall be done from top level on both sides successively to the lower levels in dam centre. Excavation works shall be organized in a manner not to deteriorate already done works.

The uncovered surface at trench bottom and trench sides shall not be mechanically damaged (e.g. by earth machines).

The Contractor is responsible for a continuous and effective drainage and the provision of all required dewatering and pumping equipment, including emergency pumps. The water shall be disposed in downstream direction and outside of the dam foundation area.

If any temporary drain will be excavated in the foundation area, the ditch needs to be free from loose, unsuitable or wet soil. The ditch shall be backfilled using the same procedure as for the embankment works. The fill material shall be similar to the surrounding foundation conditions and shall be approved by the Engineer.

Excavation soils shall be dumped on storage place(s) as selected by the Contractor and approved by the Engineer.

Suitable excavation material from the trench excavation can be used as shell material if explicitly approved in written by the Engineer. The Contractor shall submit the required suitability tests as specified in Section 2.6.3.

After excavation, the core foundation needs written approval by the Engineer. The Contractor shall proceed with the filling works immediately upon approval, but latest within 7 days.

2.6.2 Dam Foundation

2.6.2.3 Scope

The foundation area of the dam, including the foundation of the bottom outlet and the spillway, shall be carefully prepared by the Contractor.

2.6.2.4 Foundation at the Core Trench

The foundation surface shall be shaped to provide a sufficiently regular surface. Final slopes shall be 1 : 1 (V : H) or flatter. However, the surface shall be kept rough to ensure an
effective connection between the foundation and the core material.

The rock surface has to be carefully cleaned by the Contractor. Joints and voids shall be pruned by air pressure or high pressure water treatment (or combined air / water jetting) to remove loose or unsuitable material. The air / water jetting shall reach to an adequate depth, i.e. three times the width of the opening, or as defined by the Engineer. All loose material, that an air / water jet missed, shall be removed by handwork (e.g. barring, picking, brooming) and disposed at a location outside of the dam foundation area as approved by the Engineer.

Cleaning shall be started at the dam abutments and continued in the direction to the deepest point at the river course.

The Contractor shall remove all water from cleaning operations by vacuuming, or blotting with soil and wasting the wet material just before the placement of core material. Larger water quantities may be removed by pumping (compressed air will not be allowed).

2.6.2.5 Dental Treatment

Dental concrete shall be used to close the treated rock surface, i.e. fill or shape foundation irregularities, such as holes, grooves, vertical surfaces, overhangs, and other irregularities, such as previously cleaned out large joints, voids, shear zones, etc.

Dental treatment shall be done with shotcrete. The shotcrete shall have a thickness of $\geq 2$ cm and/or as instructed by the Engineer. Alternatively, dental treatment may be done by another appropriate method by mortar filling / plastering. Filling / plastering shall be done by hand work.

The rock surface should be thoroughly cleaned and moistened before concrete placement.

Steppings shall be not more than 10 cm. The inclination of steppings shall be not steeper than 1:1. Irregularities or steps should be excavated or treated with dental concrete. Overhangs should be trimmed, or the undercut below the overhang should be filled with dental concrete.

Concrete mix proportions should provide a 28-day strength of 25 N/mm². The maximum aggregate size should be less than one-third the thickness of the slab.

The finished surface shall be rough and uneven. Dental concrete should be cured by water. Concrete cracking shall be avoided.

Core material shall not be placed over dental concrete for at least 72 hours after concreting (or until 70 % of design strength is achieved).

All loose mortar / cement materials resulting from shotcrete or filling with mortar / plastering works shall be removed.
Before commencing the works, the Contractor shall submit his Method Statement on treatment of the rock foundation to the Engineer for approval.

**2.6.2.6 Constant head Injection Tests and Packer Tests (water pressure tests)**

The dam (core trench) will mainly be founded on weathered rock (granite). Therefore, it can be assumed that curtain and consolidation grouting is needed. In order to verify this, the Contractor shall perform constant head injection tests at the weathered rock foundation and packer tests (water pressure tests) at the rock foundation. The Contractor has to provide for all relevant test equipment, i.e. packer test equipment and drilling rig including all required equipment and material. Packer tests (depth of 20 m) shall be performed along the dam axis in a distance of every 20 m and/or as instructed by the Engineer.

By packer tests the permeability (Lugeon value) of the bedrock will be checked, which provides information about grouting requirements as follows:

- **Lugeon < 5 l/s and drill m:** The borehole shall be filled with mortar. The next borehole shall be drilled at a distance of 20 m and tested by packer test.

- **Lugeon ≥ 5 l/s and drill m:** The borehole shall be grouted (pressure stages 4 bar to 10 bar). Then, it will have to be decided how to proceed regarding grouting works in close cooperation with the Engineer.

**2.6.2.7 Foundation below Shell Zones**

Areas with unsuitable soil (i.e. soft grey silts, which are encountered at some parts in the foundation area under the red sand clays) have to be excavated on a length of about 125 m along the river course and replaced by fill material (shell material). The excavation depth will be up to 4 m and the width of the excavation lane up to 10 m on each side (exchange volume max. 10,000 m³).

At both abutment sides of the dam (beyond the river course / centre part of the dam) the overburden consists of slightly gravelly clayey sands. Usually, stripping of topsoil by 30 cm to 40 cm and compaction is sufficient.

At the right dam abutment weathered rock is encountered after 2 m to 3 m. The overburden is mostly suitable for shell foundation. At some areas of the shell foundation soft parts of grey silt were encountered which shall be excavated and replaced by compacted fill material (shell material) in layers not exceeding 30 cm compacted thickness.

At the left dam abutment weathered rock is encountered at a depth of maximum 5 m and at the spillway location at a depth of 2 m. Generally, the overburden is considered as suitable
for foundation. Nevertheless, the foundation area might also require some soil exchange (excavation and replacement by compacted fill material (shell material)).

Exploratory test pits may be excavated (e.g. by backhoe) as indicated by the Engineer in order to detect areas with unsuitable soil.

After excavation and replacement of unsuitable materials, the material (overburden) at foundation level shall have a water content less than 15 % and organic content less than 5 %. In case of any doubts concerning compliance with these requirements, in the opinion of the Engineer, the Contractor shall perform laboratory tests.

2.6.2.8 Foundation Preparation for Spillway and Spillway Chute

At the spillway and spillway chute soft rock is encountered after 10.5 m, respectively at the end of the chute already after 8.5 m. The soft rock is suitable for the foundation of the spillway and the spillway chute.

The preparation works for the foundation shall be performed by the Contractor as specified in Section 2.2.5 of the General Technical Specifications and as required by the Engineer.

2.6.2.9 Compaction Requirements

Where the dam or the spillway is founded on soils the foundation area shall be compacted. After compaction, the following compaction requirement needs to be proven by the Contractor. However, the compaction criteria may be varied along the foundation interface at the discretion of the Engineer.

Degree of compaction: \( D_{pr} \geq 95 \% \) (modified proctor)

2.6.3 Shell Zone

2.6.3.1 Scope

The dam (upstream slope 1 : 2.5, downstream slope 1 : 2.5, crest 6 m) shall be constructed to the limits, lines, grades and levels shown on the Drawings.
2. Soil and Geology Specification

2.6.3.2 Material

The shell zone material shall consist of gravelly, silty, clayey sand, classified as SM, SC, GC, CL according to USCS. The material shall comply with the specification in Table 2.6-1:

Table 2.6-1 Shell Material specification According to USCS

<table>
<thead>
<tr>
<th>Soil-mechanical parameter</th>
<th>Shell material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain size distribution</td>
<td></td>
</tr>
<tr>
<td>Stones &gt; 75 mm</td>
<td>%</td>
</tr>
<tr>
<td>Gravel 4.75~75 mm</td>
<td>%</td>
</tr>
<tr>
<td>Sand 0.075~4.75 mm</td>
<td>%</td>
</tr>
<tr>
<td>Silt &lt; 0.075 mm</td>
<td>%</td>
</tr>
<tr>
<td>Clay &lt; 0.002 mm</td>
<td>%</td>
</tr>
<tr>
<td>Maximum grain size</td>
<td>mm</td>
</tr>
<tr>
<td>Friction</td>
<td>φ (°)</td>
</tr>
<tr>
<td>Cohesion</td>
<td>C (kN/m²)</td>
</tr>
<tr>
<td>Permeability</td>
<td>k (m/s)</td>
</tr>
<tr>
<td>Organic content</td>
<td>%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fraction</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 10</td>
<td>3</td>
</tr>
<tr>
<td>5 - 15</td>
<td>7</td>
</tr>
<tr>
<td>30 - 60</td>
<td>45</td>
</tr>
<tr>
<td>20 - 50</td>
<td>35</td>
</tr>
<tr>
<td>5 - 20</td>
<td>10</td>
</tr>
<tr>
<td>100 (&lt; 5 %)</td>
<td></td>
</tr>
<tr>
<td>≥ 25</td>
<td>or ≥ 30</td>
</tr>
<tr>
<td>≥ 10</td>
<td>≥ 5</td>
</tr>
<tr>
<td>5 × 10⁻⁸ &lt;</td>
<td></td>
</tr>
</tbody>
</table>

Unsuitable material, such as vegetation, roots, topsoil or other organic material should not be incorporated in the shell zones. Any such materials that are spread on the embankment shall be removed manually, or otherwise.

Excavated river gravel and sand will be used downstream shell zone mixed with borrow fit shell materials.

2.6.3.3 Sampling and Testing:

Suitability tests

The Contractor shall submit suitability tests every 30,000 m³ fill from each borrow area and additionally when the material properties changes. Test program: sieve / hydrometer analysis, Atterberg limits, water content, organic content, shear test, permeability test, and modified proctor test.

Acceptance of material from any particular borrow location shall not be considered as approval of the entire location but only in so far as the material continues to meet the specification requirements.

Routine tests

Sieve / hydrometer analysis, water content tests shall be performed for every 3,000 m³
Detailed Design for Muvumba Multipurpose Dam

embankment placed (resp. every 12,000 m² area of embankment works).

Shear tests and permeability tests shall be performed for every 7,500 m³ embankment placed (resp. every 30,000 m² area of embankment works).

Modified proctor tests shall be performed every 15,000 m³ embankment placed (resp. every 60,000 m² area of embankment works).

If the material placed is thought likely not to comply with the Technical Specifications, the Contractor shall carry out additional tests as directed by the Engineer.

Compaction test

Routine compaction tests shall be performed for every 1,000 m² area of embankment works (resp. every 250 m³ embankment placed).

Conventional test methods shall be performed. Alternatively, 80 % of the tests can be replaced by radiometric sounding (Troxler probe).

Compaction Requirements

Degree of compaction: average density $D_{pr} \geq 95 \%$ (modified proctor) minimum acceptable density $D_{pr} \geq 93 \%$ (modified proctor).

Results of compaction tests shall be examined in consecutive batches of 10 results, which shall conform to the following requirements:

- The average density for each batch shall be not less than 95 % of the proctor density.
- Not more than 10 % of the results in each batch shall show a compaction less than the minimum acceptable density of 93 %.

In the event that the Engineer has required carrying out proctor tests adjacent to the field density tests at the same frequency, the compaction degree shall be defined for each individual sample. Compaction results obtained in this way shall be examined as described above.

Material, which has been compacted to a density less than that required density or at water content outside the agreed range, shall be removed or re-worked and re-compacted until the required properties are achieved. In this case, the densities recorded before removal or re-compaction shall be omitted from the calculations of the average percentage compaction.

Execution of Works

The cofferdam shall be used as a kind of test field in order to develop the Contractor’s Method Statement for the shell zones. In this way, and in close collaboration with the
Engineer, the construction procedure shall be defined in order to achieve the required compaction (i.e. define construction / compaction machines, loading of rollers, number of roller passes, layer thickness, construction material, etc.).

Before commencing the construction works for the shell zones, the Contractor shall submit his Method Statement to the Engineer for approval.

The shell material shall be placed in layers not exceeding 25 cm compacted thickness, unless otherwise specified in the approved Method Statement.

After compaction the layer surface shall be cautiously scarified for bonding with the next layer.

The water content of the material shall be controlled and preconditioned at the borrow area. The material shall strictly meet the requirement, i.e. +/- 2 % of the optimum water content. In case, the material is too dry, it needs moistening after spreading at the shell zone (with scarifying). In case it is too wet, the spread material shall be exposed to dry until the required water content is achieved.

Backfilling of concrete structures located in the shell zone shall be made with approved shell material. The backfill (shell material) shall be placed in layers not exceeding 20 cm compacted thickness and compacted to the same requirements as the adjacent earthwork. Each layer shall be wetted uniformly as necessary.

Special care shall be taken during filling and compaction works along structures. Particularly, at the bottom outlet the material must be placed thoroughly against the structure, so that no gap remain between the shell material and adjacent surface. The Constrator must ensure that the compaction is done carefully by a suitable method, as approved the Engineer.

Where material is placed against the walls of spillway and bottom outlet structures, hand-held compacting equipment shall be used to achieve the required degree of compaction (i.e. no heavy machines are allowed within a distance of 2 m). At other locations, hand tamping will not be accepted unless otherwise approved by the Engineer.

2.6.4 Core Zone

2.6.4.1 Scope

The dam core (slope inclination of 2.5 : 1, width at the top 3 m) shall be constructed to the limits, lines, grades and levels shown on the Drawings.

The width at the trench bottom will be not less than 6 m. The sides of core trench will be inclined approximately 1 : 1, but not steeper than 1.5 : 1 (V : H) to avoid interferences (due to different settlements) between the core zone and adjacent foundation zones.
At locations where the actual bedrock level is deep, the core trench has to be widened at the top, i.e. jut out beyond the outer edge of the dam core. In this case, it has to be ensured that the overhanging section of the core trench has an outwardly orientated inclination of > 1 % as shown on the Drawings.

The following specifications on material and filling works refer to both, the dam core and the core trench.

### 2.6.4.2 Material

The core zone material for both, dam core and core trench, shall consist of sandy, silty, clay, classified as CL, SC according to USCS. The material shall comply with the specifications in Table 2.6-2:

<table>
<thead>
<tr>
<th>Soil-mechanical parameter</th>
<th>Shell material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stones &gt; 75 mm</td>
<td>%</td>
</tr>
<tr>
<td>Gravel 4.75~75 mm</td>
<td>%</td>
</tr>
<tr>
<td>Sand 0.075~4.75 mm</td>
<td>%</td>
</tr>
<tr>
<td>Silt &lt; 0.075 mm</td>
<td>%</td>
</tr>
<tr>
<td>Clay &lt; 0.002 mm</td>
<td>%</td>
</tr>
<tr>
<td>Maximum grain size</td>
<td>mm</td>
</tr>
<tr>
<td>Friction</td>
<td>( \phi (°) )</td>
</tr>
<tr>
<td>Cohesion</td>
<td>C (kN/m²)</td>
</tr>
<tr>
<td>Permeability</td>
<td>k (m/s)</td>
</tr>
<tr>
<td>Organic content</td>
<td>%</td>
</tr>
</tbody>
</table>

Atterberg limits shall be above the A-line in the Casagrande’s plasticity chart with a liquid limit ranging from \( w_l = 25 \% \) to 50 % and a plasticity index from \( I_p = 7 \% \) to 30 %.

Unsuitable material, such as vegetation, roots, topsoil or other organic material should not be incorporated in the core zones. Any such materials that are spread on the embankment shall be removed manually, or otherwise.
2. Soil and Geology Specification

2.6.4.3 Sampling and Testing

Suitability tests

The Contractor shall submit suitability tests every 15,000 m³ fill from each borrow area and additionally then the material properties changes. Test program: sieve / hydrometer analysis, Atterberg limits, water content, organic content, shear test, Oedometer test, permeability test, modified proctor test.

Acceptance of material from any particular borrow location shall not be considered as approval of the entire location but only in so far as the material continues to meet the specification requirements.

Routine tests

Sieve / hydrometer analysis, Atterberg limits, water content and permeability tests shall be performed for every 1,500 m³ embankment placed (resp. every 7,500 m² area of embankment works).

Shear tests shall be performed for every 3,000 m³ embankment placed (resp. every 15,000 m² area of embankment works).

Modified proctor tests shall be performed every 7,500 m³ embankment placed (resp. every 37,500 m² area of embankment works).

If the material placed is thought likely not to comply with the specifications, the Contractor shall carry out additional tests as directed by the Engineer.

Compaction test

Routine compaction tests shall be performed for every 1,000 m² area of embankment works (resp. every 200 m³ embankment placed).

Conventional test methods shall be performed. Alternatively, 80 % of the tests can be replaced by radiometric sounding (Troxler probe).

Compaction Requirements

Degree of compaction: average density Dpr ≥ 95 % (modified proctor) minimum acceptable density Dpr ≥ 93 % (modified proctor) Results of compaction tests shall be examined in consecutive batches of 10 results, which shall conform to the following requirements:

- The average density for each batch shall be not less than 95 % of the proctor density.
- Not more than 10 % of the results in each batch shall show a compaction less than the minimum acceptable density of 93 %.
In the event that the Engineer has required carrying out proctor tests adjacent to the field density tests at the same frequency, the compaction degree shall be defined for each individual sample. Compaction results obtained in this way shall be examined as described above.

Material, which has been compacted to a density less than that required density or at water content outside the agreed range, shall be removed or re-worked and re-compacted until the required properties are achieved. In this case, the densities recorded before removal or re-compaction shall be omitted from the calculations of the average percentage compaction.

Execution of Works

The cofferdam shall be used as a kind of test field in order to develop the Contractor’s Method Statement for the core zone. In this way, and in close collaboration with the Engineer, the construction procedure shall be defined in order to achieve the required compaction (i.e. define construction / compaction machines, loading of rollers, number of roller passes, layer thickness, construction material, etc.).

Before commencing the construction works for the core zone, the Contractor shall submit his Method Statement to the Engineer for approval.

The core material shall be placed in layers not exceeding 20 cm compacted thickness, unless otherwise specified in the approved Method Statement. In the core trench, the layers thickness shall be limited to 15 cm compacted thickness. Here, the water content shall be slightly on the dry side of the proctor curve.

The water content of the material shall be controlled and preconditioned at the borrow area. The material shall strictly meet the requirement, i.e. +/- 3 % of the optimum water content. In case, the material is too dry, it needs moistening after spreading at the shell zone (with scarifying). In case it is too wet, the spread material shall be exposed to dry until the required water content is achieved.

After compaction the surface of the layer shall be cautiously scarified for bonding with the next layer.

If shrinkage cracks due to drying occur in the exposed surface, the material shall be excavated back to the full depth of any cracks and the excavated material removed to spoil (disposal location). This work shall be carried out at the Contractor’s own cost.

Backfilling of concrete structures located in the core zone shall be made with approved core material. The backfill (core material) shall be placed in layers not exceeding 15 cm compacted thickness and compacted to the same requirements as the adjacent earthwork. The water content shall be slightly on the dry side of the proctor curve. Each layer shall be wetted uniformly as necessary.

Special care shall be taken during filling and compaction works along structures. Particularly,
at the bottom outlet and at anti-seepage collars the material must be placed thoroughly against the structure, so that no gap remain between the core material (clay) and adjacent surface. The Constructor must ensure that the compaction is done carefully by a suitable method, as approved the Engineer.

Where material is placed against the sides of the core trench, against steep rock faces or the walls of spillway and bottom outlet structures, hand-held compacting equipment shall be used to achieve the required degree of compaction (i.e. no heavy machines are allowed within a distance of 2 m). At other locations, hand tamping will not be accepted unless otherwise approved by the Engineer.

2.6.5 Test fields (for shell / core zones)

The cofferdam shall be used as a kind of test field in order to develop the Contractor’s Method Statement for the dam embankment.

Generally, the cofferdam shall be constructed with shell material. Nonetheless, a predefined area of the cofferdam shall be constructed with core material.

Prior to starting the works at the test field the Contractor shall submit to the Engineer a Method Statement defining construction methods, dimensions of test field (minimum 25 m × 50 m), ramps, programme of trial compaction tests and survey, etc.

Different layer thickness with varying water content (± 3 % of optimum water content) shall be tested, i.e. compacted layer thickness of 25 cm, 30 cm and 35 cm for shell material and 20 cm, 25 cm and 30 cm for core material.

Additional to the tests defined in Sections 2.6.3 and 2.6.4 of the Particular Technical Specifications, the level of each layer shall be precisely surveyed every 2 passes of the roller in order to determine the settlement of the layer.

In the test field, the frequency of testing shall be approximately three times higher than for the other embankment as defined in Section 2.6.3 and 2.6.4 of Particular Technical Specifications, as is specified in Table 2.6-3
### Table 2.6-3 Test frequency for Field Tests

<table>
<thead>
<tr>
<th>Test field (Upstream cofferdam)</th>
<th>Test frequency (every m³ resp. m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shell material</td>
</tr>
<tr>
<td>Suitability tests</td>
<td>10,000 m³</td>
</tr>
<tr>
<td>Routine tests</td>
<td></td>
</tr>
<tr>
<td>- Sieve/hydrometer analysis, Atterberg limit</td>
<td>1,000 m³</td>
</tr>
<tr>
<td>- Water content</td>
<td>2,500 m³</td>
</tr>
<tr>
<td>- Permeability tests</td>
<td>2,500 m³</td>
</tr>
<tr>
<td>- Shear tests</td>
<td>5,000 m³</td>
</tr>
<tr>
<td>- Modified proctor tests</td>
<td>5,000 m³</td>
</tr>
<tr>
<td>- Compaction tests</td>
<td>2,500 m³</td>
</tr>
</tbody>
</table>

- But not less than one test per test scenario (i.e. at least one test for each layer thickness, compaction equipment, and number of roller passes, etc.).
- In case, the Contractor intends to use radiometric sounding (Troxler probe) for compaction control, the Troxler probe shall be calibrated in the test fields (for shell and core materials), refer to Section 2.2.2 of General TS.

In detail, the frequency of the tests shall be determined from previous test results, the quality of the material revealed during such tests and the uniformity of such quality. The frequency may be amended as required by the Engineer.

In the event that individual proctor tests result in widely ranging values for proctor density and optimum water content the Engineer may require carrying out proctor tests at the same frequency as field density tests, using materials taken from adjacent locations. This may be applied during cofferdam construction and from time to time during construction of the final dam embankment.

If the material placed is thought likely not to comply with the Technical Specifications, the Contractor shall carry out additional tests as directed by the Engineer.

In this way, and in close collaboration with the Engineer, the construction procedure (i.e. define construction / compaction machines, loading of rollers, number of roller passes, layer
2. Soil and Geology Specification

thickness, construction material, etc.) shall be calibrated in order to achieve the required compaction. The proposed Method Statement including all test results and their interpretation shall be submitted promptly to the Engineer for approval.

2.6.6 Filter Zone

2.6.6.1 Scope

The filter zone, consisting of an inclined chimney filter (downstream of the core zone), a filter blanket (gravel filter sandwiched by two sand filter layers) with toe drain and a trench filter (downstream of the core trench), shall be constructed to the limits, lines, grades and levels shown on the Drawings).

Material:

The filter material shall be obtained from river deposit. The material must have a permeability of \( k_f \geq 10^{-4} \) m/s.

Filter sand 0.2/6 mm (fines < 0.075 mm: < 5 %) shall be used for the chimney filter, the lower and the top layer of the blanket and the trench filter. The middle layer of the blanket shall be gravel 2~60 mm.

Nonetheless, it is the Contractor’s obligation to ensure the filter stability of the layers (shell – filter - subsoil). Before exploitation, analyses of the filter stability have to be submitted to the Engineer for approval.

Alternatively, filter material may be gained from quarry operation. In this case, crushed rock aggregate 2~12 mm (fines < 0.075 mm: < 5 %, U < 10) shall be used. Using crushed rock aggregate the filter blanket needs to be surrounded by geotextile.

2.6.6.2 Sampling and Testing

Suitability tests:

The Contractor shall submit suitability tests every 5,000 m³ fill from each borrow area and additionally then the material properties changes. Test program: sieve analysis and relative density test.

Acceptance of material from any particular borrow location shall not be considered as approval of the entire location but only in so far as the material continues to meet the specification requirements.
Routine tests
Sieve analysis and permeability tests shall be performed for every 750 m³ filter placed (resp. every 3,000 m² area of embankment works).

Compaction test
Routine density tests shall be performed for every 750 m² area of embankment works (resp. every approx. 200 m³ embankment placed).

Compaction Requirements
Degree of compaction: sand filter DD ≥ 90 % (relative density, average)
gravel filter DD ≥ 80 % (relative density, average)

Execution of Works
The filter material shall be placed in layers not exceeding 25 cm compacted thickness.
In order to avoid contamination of the filter, filter material shall be always placed in advance of the shell material. In this way the surface of the filter zone will be at one layer above the shell zone surface.
It is of utmost importance to ensure that the filter zone is not contaminated by other materials. Hence, the Contractor shall ensure that constructional traffic does not cross such sections of the embankment or otherwise contaminate the filter material. If, in the Engineer’s opinion, contamination does take place, the contaminated material shall be removed. The Contractor shall have no claim for payment for such material to be removed.

2.6.7 Geotextile

2.6.7.1 Scope
Geotextiles are designed at the core zone, both on top and downstream of the core as well as downstream of the core trench as shown on the Drawings.

Material:
Geotextiles shall be nonwoven and needle-punched (mechanically bonded) according to EN 13251 and EN 13252 “Geotextiles and geotextile related products - Required characteristics for use in earthworks, foundations and retaining structures” respectively “- Characteristics required for use in drainage systems”, both 2000 / A1: 2005.
The geotextile should compile with the following specifications:
2. Soil and Geology Specification

- raw material PP
- weight per unit area ISO 9664 ≥ 300 g/m²
- thickness ISO 9863-1 ≥ 2 mm
- tensile strength (longitudinal / transversal) ISO 10319 ≥ 20 kN/m
- static puncture resistance (CBR test) ISO 12236 ≥ 3,800 N
- water permeability, normal to plane ISO 11058 ≥ 0.05 m/s
- opening size ISO 12956 ≤ 0.09 mm

The acceptance of use of any type of geotextile from the Contractor will be decided after the submission of its characteristics to the Engineer. The geotextile can be used after the written approval of the Engineer.

2.6.7.2 Ultraviolet (UV) Radiation Resistance

The requirements should contain the UV radiation reaction of the geotextile and the measures taken by the industry of production. The geotextiles should be always delivered to the worksite packed with suitable protecting wrapping against UV radiation. Proportionally to the sensitivity of the geotextile in UV radiation, the placement must be regulated in correlation with the remaining of the site work, in order to have the geotextile covered in a way to ensure it from UV radiation. The lime interval should be such to maintain at least a rate of 90 % of the initial tensile strength.

2.6.7.3 Execution of Works

Immediate covering of geotextiles is the best protection from UV radiation. Geotextiles should not remain uncovered for longer than two weeks or as specified by the Manufacturer. In the case the geotextile remains exposed in UV radiation beyond the allowed time then it is considered, conventionally, as useless and should be replaced at no extra cost to the Contract.

Geotextiles are to install crosswise to the dam axis (from top to bottom).

Geotextiles shall be covered by using „nd tipping“ without disturbing the already placed geotextile, i.e. no transport vehicles and earthworks machines are allowed to drive on geotextile, it is only allowed to drive on covered geotextiles (covered by at least one soil layer, d ≥ 25 cm).
Joints of geotextiles should be made according to the instructions of the Manufacturer. However, for the jointing there should be overlapping of at least 0.5 m and/or according to Manufacturer’s guidelines. Overlapping of geotextiles has to be comprised in the prices per unit.

Embedding length of geotextiles in natural ground or mineral construction material shall be at least 0.8 m if not otherwise specified.

Works and all labour, equipment, materials, and all other costs of any nature necessary to ensure satisfactory completion are to include in the unit rates.

### 2.6.8 Required Accuracy and Cambering

#### 2.6.8.1 Reference Drawing
- Reference Section of Technical Specifications: Shell zone, Core zone, Filter zone

#### 2.6.8.2 Scope
The levels and thicknesses of the various zones, such as shell, core and filter zones, or layers shall be according to the Drawings.

The accuracy of slopes or adjacent zones shall be +/- 5 cm.

The final level of the embankment crest shall be +/- 1 cm (considering cambering).

In the setting out and construction of the embankment an allowance shall be made for post-construction settlement.

### 2.6.9 Upstream Slope Protection

#### 2.6.9.1 Scope
The upstream slope shall be protected by rip-rap \((d = 0.4 \text{ m})\) on 0.15 m bedding layer as shown on the Drawings.

#### 2.6.9.2 Material
The rip-rap shall consist of rock fragments with block diameters varying from 100 mm to 300 mm with diameters < 100 mm of max. 5 %.
The rock fragments shall be dense, sound, and resistant to abrasion and shall be free from cracks, seams, and other defects, that would tend to increase unduly their destruction by water.

Samples for rip-rap and rock armour prepared in accordance with applicable designations of the US Bureau of Reclamation’s “Concrete Manual” (8th edition), shall meet the following requirements when tested by the procedures described in the respective designation.

Table 2.6-4  Specification of Rip-rap

<table>
<thead>
<tr>
<th>Test</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific gravity (saturated surface-dry basis)</td>
<td>2.6</td>
</tr>
<tr>
<td>Soundness (sodium sulphate method)</td>
<td>10% loss of weight after 5 cycles</td>
</tr>
<tr>
<td>Abrasion (using Los Angeles machine grading A)</td>
<td>10% loss of weight after 500 revolution</td>
</tr>
</tbody>
</table>

The bedding material, crushed stones 6~60 mm, well-gradsed, shall be from dense, sound rock. The rock shall have less than 10 % loss in the soundness test and less than 35 % loss in the Los Angeles test.

2.6.9.3 Execution of Works

Approved material shall be transported without intermediate handling direct to the point of final use. Where it shall be dumped and graded off in a manner to ensure that the larger rock fragments are uniformly distributed and the smaller rock fragments fill the spaces between the larger rock fragments to form compact uniform layers of rip-rap of the specified thicknesses as shown on the Drawings.

Hand placing will be required to the extent necessary to secure the results specified above. Bigger voids shall be filled by handplacing (wedging with smaller rip-rap stones). The surface of the slope shall be flat, i.e. stones shall not stand out of the surface line more than 7 cm. In case of doubts, the Contractor is requeststed to prove a density of at least 19 kN/m$^3$ of the rip-rap layer.

The work shall be performed by the Contractor in accordance with Section 2.3.1.
**2.6.10 Downstream Slope Protection**

**2.6.10.1 Scope**

The downstream slope shall be protected with a layer of topsoil, which shall be planted with local grass (sodding or seeding of grass). The Contractor shall agree the method with the Engineer.

At the downstream dam toe in the area of the toe drain, the slope shall be protected by rip-rap \((d = 0.4 \text{ m})\) as specified on the Drawings.

**2.6.10.2 Material**

Topsoil stripped from areas to be occupied by the Works, and temporarily stored in triangular heaps, shall be use.

Additionally, topsoil stripped from the borrow areas within the reservoir area may be used as specified by the Engineer.

For greening local grass shall be used. The rip-rap at the dam toe shall be of the same kind as for the upstream slope protection.

**2.6.10.3 Execution of Works**

The downstream slope protection shall be applied by spreading and levelling two or three stages behind the construction of the rest of the embankment.

The grass (wether sodding or seeding) shall be maintained by keeping wet. The surface shall be protected against damages and erosions. Eroded spots shall be repaired immediately. The grass shall be cut halfyearly, or whenever necessary. By the end of the construction period (and as well at the end of the defect notification period), the downstream slope protection shall be complete, i.e. dense grass, without skips or spots of erosion.

**2.6.11 Embankment Drainage**

**2.6.11.1 Scope**

The work shall be carried out to the limits, lines, grades and levels shown on the Drawings and/or as approved by the Engineer. The work shall be carried out and finished all to the satisfaction of the Engineer.
2.6.11.2 Surface Water / Drainage Canal

Surface water runoff is collected in a drainage canal (stone pitching in mortar). On the left hand side of the bottom outlet the drainage canal is located along the downstream dam toe as shown on the Drawings. On the right hand side of the bottom outlet the drainage canal of the road is used.

Seepage / drain pipe:

A drain pipe (perforated HDPE pipe, Ø 150 mm) shall be placed along the downstream dam toe. At the deepest point of the dam toe the collected water shall be directed into downstream direction (unperforated HDPE pipe, 200 mm). The collection pipe ends in a concrete box.

For measurement of the seepage water amount a V-notch weir is to install at the box before entering into the open drain.

The Contractor shall submit detailed Working Drawings considering a pipeline gradient in flow direction of $\geq 0.5\%$ and product details, such as segment length, bend ($15^\circ$, $30^\circ$, or similar), wye ($45^\circ$, $90^\circ$, or similar), etc.

The unite price includes all accessories (such as pipe fittings, couplings, bends, wyes, etc.) necessary for the Works.

2.6.11.3 Material

The drain pipes shall comply with DIN 16961.

- nominal diameter: DN 150 (perforated),
- DN 200 (unperforated)
- material: HDPE
- type: corrugated, including pipe couplings
- ring stiffness SN 4
- drain pipe: slot opening adapted to the filter material, surrounded with filter cloth (geotextile)
- endcaps (HDPE) at both ends of the drain pipe

The filter cloth (geotextile) shall be nonwoven and needle-punched (mechanically bonded) according to EN 13251 and EN 13252 “Geotextiles and geotextile related products - Required characteristics for use in earthworks, foundations and retaining structures”

The filter cloth (geotextile) should compile with the following specifications:

- raw material PP
- weight per unit area (ISO 9664) ≥ 300 g/m²
- water permeability, normal to plane (ISO 11058) k > 10⁻³ m/s
- opening size (ISO 12956) O₉₀,chosen = 0.8 to 1.0 · O₉₀,allow
  O₉₀, allow < 5 · d₁₀ · √U; U = d₆₀ / d₁₀
  O₉₀, allow < d₉₀
  (d₁₀, d₆₀, d₉₀ of filter zone material)
- ultraviolet (UV) radiation resistance refer to Section 2.6.7

The acceptance of use of any type of geotextile from the Contractor will be decided after the submission of its characteristics to the Engineer. The geotextile can be used after the written approval of the Engineer.

### 2.6.11.4 Execution of Works

Joints of geotextiles should be made according to the instructions of the Manufacturer. However, overlapping of at least 10 cm shall be ensured, or as instructed by the Engineer. Overlapping of geotextiles has to be comprised in the prices per unit.

After pipe laying, the filter zone material shall be placed and uniformly compacted by a suitable method approved by the Engineer. Care shall be taken that the pipe is neither damaged nor displaced.

After construction functioning tests shall be performed in the presence of the Engineer.

### 2.7 Borrow Areas

#### 2.7.1 Scope

The provision of suitable material for embankment construction in sufficient quantity is in the responsibility of the Contractor.

Unless otherwise directed by the Engineer, mineral construction material shall be obtained
from designated borrow areas as shown on the Drawings, and from excavations. Other borrow areas proposed by the Contractor shall be approved in written by the Engineer.

Preferably, borrow areas shall be located within the limits of the reservoir (this particularly applies for shell and core materials).

2.7.2 Execution of Works

To facilitate efficient planning of his Method Statement, the Contractor shall carry out at his own expense test pits in the borrow areas to determine the quantity, condition and type of materials that will be encountered during exploitation.

The Contractor shall submit to the Engineer his Method Statements for each type of material. Besides the proposed construction method, each Method Statement shall comprise a plan of earthmoving and volume estimates, etc. The Contractor shall not start site clearance or excavation at any borrow area until the Engineer’s permission and approval of the Method Statement in writing.

The Contractor shall work the borrow areas in a systematic manner and shall arrange his Method Statement in such a way that deterioration of the materials in the borrow areas are minimized before and during excavation. The Contractor shall provide all necessary drainage and pumping to ensure that the borrow areas are at all times free of standing water.

Different types of material from the borrow areas shall be kept separately, and shall be stored in approved areas not adjacent to the stream beds or any road. Material that is unsuitable for use shall be disposed of.

The Contractor shall construct and maintain all necessary access roads and bridges to the borrow areas.

After finishing exploitation works, the Contractor shall profile respectively level the used area to such an extent that there do not remain any steep slopes which might cause slips or falls. The profiling / leveling works shall be done as instructed by the Engineer.

For further specifications for the different materials, it is referred to the following Sections.

2.7.3 Shell and Core Material

Mineral construction materials for shell and core zones shall be obtained from the designated borrow areas in and near the reservoir area as shown on the Drawings.

Exploitation of the borrow areas shall be carried out in 100 m long stages, to be agreed with the Engineer.
The Contractor shall prevent slips of material from the sides of the excavation and shall provide all necessary temporary support, if needed.

The material shall be preconditioned in the borrow area before excavation. Where the natural moisture content of the fill material in the borrow areas is higher than required the fill material shall be exposed to the air, scarified and ploughed in order to reduce the moisture content uniformly prior to excavation. If, before excavation operations at any location in the borrow areas, there is a shortage of moisture, then moisture shall be introduced into the borrow areas by irrigation, at least 3 days in advance of excavation operations. Care shall be exercised to moisten the material uniformly prior to excavation, avoiding both excessive run-off and accumulation of water in depressions.

For shell material, it is recommended to use soil from the lower part of the borrow area for construction of the downstream shell (soil with lower plasticity). The upstream shell should be constructed with soil from the upper part of the borrow area (more plastic soil, more gravelly).

For borrow areas that are located outside the reservoir and within agricultural land or within the silt trap zone of the reservoir (i.e. above FSL) the disturbed area shall be restored. That means, the existing topsoil shall be stored in triangular heaps, in areas not adjacent to the stream beds or any main road. After finishing exploitation works, the Contractor shall flatten the area and re-spread evenly the stored topsoil (d = 20 cm) to return these areas to agricultural use or to allow for planting the silt trap zone (the planting work itself is not part of this Contract). This works shall be carried out immediately after the area has been fully exploited. Existing big trees shall be protected and maintained as much as possible.

Finished ground levels within the borrow area shall have a uniform gradient to ensure adequate drainage and this will be supplemented by drainage ditches and other appropriate measures to meet this requirement. In order to meet this requirement the Contractor may excavate, remove topsoil and re-spread it over an area outside the limits of the designated borrow area.

**2.7.4 Filter Material**

Filter material shall be obtained from river deposits (sand / gravel deposits). The Contractor shall propose possible borrow areas. Long transport distances are to be included in the unit price.

One possible river deposit is located in a distance of about 40 km from the dam area.

Alternatively, filter material may be obtained either from an abandoned quarry, which is located approximately 4 km away from the dam area. Or material may be obtained from an extended rock outcrop, which is located about 800 m upstream of the dam within the reservoir area (on the left side). The rock outcrop might be used for quarry opening.
Quarry operation would require a crushing machine as well as proper processing involving screening, crushing and washing to be ensured by the Contractor.

In any case (river deposit or quarry operation) the filter material has to comply with the specifications of Section 2.6.6.

2.7.5 Rip-rap

Material for rip-rap protection (e.g. for slope protection, etc.) shall be obtained from a quarry.

Within the reservoir area and approximately 1,000 m upstream of the dam site, there is an extended granite rock outcrop, which may be used for quarry operation. Alternatively, approximately 4 km downstream of the dam site there is an abandoned quarry, which might be reopened by the Contractor.

In any case, the Contractor is responsible for all required arrangements and agreements (e.g. exploitation permit from landowners) for both, the quarry and the access to the quarry.

2.7.6 Topsoil

Topsoil (e.g. for downstream slope protection) shall be obtained from excavation areas, such as dam foundation area and borrow areas, or from within the reservoir area.

2.7.7 Bedding Material

Bedding material (e.g. for slope protection by rip-rap, other structures, etc.) is obtained from an abandoned quarry or from river deposit (refer to Section 2.7.4).

2.8 Spillway Structure

2.8.1 Excavation

2.8.1.1 Scope and Execution of Works

Excavation shall be done down to semi weathered rock and in accordance with the limits, lines, grades and levels shown on the Drawings.

Excavation shall be done in compliance with the General TS for the earthworks.

Excavation works shall include all supporting temporary works as dewatering and pumping.
The uncovered surface at trench bottom and trench sides shall not be mechanically damaged (e.g. by earth machines).

When necessary the excavation has to be performed in weathered and/or semi weathered rock with the use of pneumatic tools. No extra payment will be allowed.

In the unforeseen case that weathered rock is not encountered as per drawings and instead loose soils or very soft rock, then the excavation shall be executed more deep as directed by the Engineer.

Whenever the Engineer instructs excavation shall be executed more deep to reach suitable rock foundation conditions.

The foundation area of spillway after excavations needs the written approval by the Engineer before proceeding with concreting works.

Over excavations in bottom – after cleaning and foundation area treatment shall be refilled by dental concreting. The Engineer may instruct for “stone pitching in grout” filling of the over excavations. In the contact zone between foundation rock and fill of cavities and holes by “stone pitching in grout” the Contractor shall provide steel anchor for connecting (steel anchor: total length: 1 m - 30 cm in rock and 50 cm in “stones in mortar” filling, the rods both sides in grout/ mortar, diameter of rods not less 20 mm, spaced on area 0.50 m by 0.50 m).

Over excavation will be paid only in case of encountered loose soils. Any over excavation due to the Contractor’s fault will not be paid.

Temporary side slopes shall be stable and not steeper as 1:1 in loose soils or 2:1 (V:H) in weathered rock formations.

Excavated materials shall be dumped on approved locations of depositing outside of the spillway and dam foundation area. Excavation soils which are suitable for re-use in the dam’s embankment shell zone shall be deposit separately from waste excavation soils – without extra payment. The Contractor shall protect such temporary deposits for re-use from deteriorations by rainwater or impurities. Re-use of spillway excavation soils for embankment works (shell zone) need approval by the Engineer.

2.8.2 Foundation Treatment

2.8.2.1 Scope and Execution of Works

The foundation surface shall be shaped to provide a sufficiently regular surface. The surface shall be kept rough for effective connection between the foundation and the spillway bottom slab.
The rock surface has to be carefully cleaned by the Contractor. Joints and voids shall be pruned by air pressure or high pressure water treatment (or combined air / water jetting) to remove loose or unsuitable material. The air / water jetting shall reach to an adequate depth, i.e. three times the width of the opening, or as defined by the Engineer. All loose material, that an air / water jet missed, shall be removed by handwork.

The Contractor shall remove all water from blinding operations.

### 2.8.2.2 Dental Concrete

Dental concrete shall be used to fill or shape foundation irregularities in the rock surface such as holes, grooves, vertical surfaces, overhangs, and other irregularities (large joints, voids, etc.).

Irregularities or steps \( \geq 15 \text{ cm} \) should be excavated or treated with dental concrete. Overhangs should be trimmed, or the undercut below the overhang should be filled with dental concrete. Placing a concrete slab over a zone of closely spaced irregularities may be appropriate in local areas.

### 2.8.3 Concrete Works, General

The following provisions shall be regarded by the Contractor in particular:

- The spillway is expected to be founded on Augen gneiss.
- The founding ground will be checked after the excavation and if required so the necessary alterations caused by the placement of crushed stone revetment or with the approval and under the auspice of the Supervision.
- The excavation lines and levels shown in the drawings are the minimum required.
- Levels and structure coordinates must be marked by a qualified surveyor.
- The excavation method so as to achieve the prescribed excavation lines is the contractor's responsibility. The excavation lines can be altered during construction. The Supervision must be informed and grant its approval prior to the works commencement.
- The contractor must provide a Concrete Construction Joint Schedule based on his know-how, personnel and equipment used. The Concrete Construction Joint must receive the Supervision's approval. Founding on a deeper level must be accommodated in the calculations and drawings.
• Water - Stop elastic membranes to be placed at all Contraction and Construction joints below level 1629.00 upstream the downstream filters.

• Implementation of the drawings for construction adheres to full compliance with the Specifications

• Levelling/ blinding concrete C12/16

• Concrete for slabs, abutments, walls C25/30; reinforcing steel B500C

• Concrete cover 60 mm unless otherwise specified

The spillway chute is designed as rock chute with anchored stone dissipaters as shown in the drawings. The “tepped Rock Chute” is to be formed in solid rock layer. Drawings in this regard are only indicative. The depth of rock chute is depending on site conditions. Steps to be formed with a relation of step height to step length of H/L = 0.2 and a step height 1.5 < H < 2.5 m.”

Backfilling of walls and other structures shall be done in accordance with the General Technical Specifications for earthworks, in particular Section 2.2.6.

The concrete face of walls towards the core zone of the dam shall be rough and moistened before the core clay is placed in layers against the structure walls (see drawing NMK20/010-9, the area of core zone in contact with the spillway concrete side walls). The material is core zone material (clay). Placing and compacting of the clay in particular regard of Section 2.2.6.1 of General TS and Section 2.6.1 (clay in layers – height not more than 15 cm, clay to be placed with water content between wopt +/-2 % and with modified proctor not less 97%, employing small equipment for compaction and hand tools; soil compaction and quality test (permeability test) shall be done one for each layer on left side and one for each layer right side.

Backfill at sections where the concrete face of walls are towards the embankment shell zone the backfill material shall be from shell material borrow area. Backfilling works of shell material: height of layers not more than 20 cm, compaction to 97 % modified proctor and water content wopt +/-2 %. Compaction and routine testing shall be done for every second layer on left side and every second layer on right side.

Outside of the dam crossing section the backfilling and materials according to the technical specifications for earthworks.
3. Structural Specification

3.1 Concrete Works

3.1.1 Cement

The cement must conform to the Norm EN197-1:2000 “Cement: Composition, specifications and compliance criteria” (Type CEM I, CEM II/A-M, CEM II/A-L and CEM II/A-P). Unless it is specified otherwise in the contract, the concrete must have minimum typical strength at 28 days 42.5 MPa and must be type N. The Contractor must submit to the Engineer the type of cement that will be used.

The Contractor must take all necessary measures to protect the cement from exposure to humidity. The Engineer reserves the right to demand the removal from the site of cement that has been influenced by humidity.

The Engineer reserves the right to demand at any time from the Contractor to carry out laboratory test to verify whether the quality of the cement delivered on the Site is according to the specifications. Whatever quantity of cement is not according to the specifications will not be used and will be removed from the site.

3.1.2 Aggregates

The sand and gravel must conform to the Norm EN12620:2002 “Aggregates for Concrete”, and the requirements listed in Table 3.1-1 must be respected.

Table 3.1-1 Aggregates for Concrete

<table>
<thead>
<tr>
<th>Paragraph Norm</th>
<th>Characteristic</th>
<th>Coarse Aggregates</th>
<th>All-in Aggregates</th>
<th>Fine Aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.4</td>
<td>Particle shape</td>
<td>Maximum allowable Class F120</td>
<td>Maximum Allowable class F120. It refers to coarse part</td>
<td></td>
</tr>
<tr>
<td>4.2</td>
<td>Particle size</td>
<td>The ratio d/D of the product is declared</td>
<td>The ratio d/D of the product is declared</td>
<td>The ratio d/D of the product is declared</td>
</tr>
<tr>
<td>5.5</td>
<td>Particle density</td>
<td>The value shall not be smaller than 2,00Mg/m³ as dry density</td>
<td>The value shall not be smaller than 2,00Mg/m³ as dry density</td>
<td>The value shall not be smaller than 2,00Mg/m³ as dry density</td>
</tr>
</tbody>
</table>
### EN12620:2002: Aggregates for Concrete

<table>
<thead>
<tr>
<th>Paragraph Norm</th>
<th>Characteristic</th>
<th>Coarse Aggregates</th>
<th>All-in Aggregates</th>
<th>Fine Aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.6</td>
<td>Fines content</td>
<td>Maximum allowable class F1.5</td>
<td>Maximum allowable class F3</td>
<td>Maximum Allowable class F10. For natural sand produced from natural gravel maximum allowable class F3.</td>
</tr>
<tr>
<td>5.2</td>
<td>Resistance to fragmentation</td>
<td>Maximum Allowable class LA35</td>
<td>Maximum Allowable class LA35. It refers to the coarse part</td>
<td></td>
</tr>
<tr>
<td>5.4.1</td>
<td>Resistance to polishing</td>
<td>The PSV class is declared for the concrete used as pavement for vehicles</td>
<td>The PSV class is declared for the concrete used as pavement for vehicles. It refers to the coarse part. (I)</td>
<td></td>
</tr>
<tr>
<td>5.4.2</td>
<td>Resistance to abrasion</td>
<td>The AAV class is declared for the concrete used as pavement for vehicles</td>
<td>The AAV class is declared for concrete used as pavement for vehicles. It refers to the coarse (I)</td>
<td></td>
</tr>
<tr>
<td>6.2</td>
<td>Chlorides</td>
<td>It is declared for aggregates used for reinforced concrete. The allowable content must not exceed 0.1%</td>
<td>It is declared for aggregates used for reinforced concrete. The allowable content must not exceed 0.1%</td>
<td>It is declared for aggregates used for reinforced concrete. The allowable content must not exceed 0.1%</td>
</tr>
<tr>
<td>6.3.1</td>
<td>Acid sulfates</td>
<td>Maximum Allowable class ASO.8</td>
<td>Maximum Allowable class ASO.8</td>
<td>Maximum allowable class ASO.8</td>
</tr>
<tr>
<td>6.3.2</td>
<td>Total sulfur</td>
<td>The value must not exceed 1%</td>
<td>The value must not exceed 1%</td>
<td>The value must not exceed 1%</td>
</tr>
</tbody>
</table>
3. Structural Specification

### EN12620:2002: Aggregates for Concrete

<table>
<thead>
<tr>
<th>Paragraph</th>
<th>Characteristic</th>
<th>Coarse Aggregates</th>
<th>All-in Aggregates</th>
<th>Fine Aggregates</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5</td>
<td>Water absorption</td>
<td>The value must not exceed 4%</td>
<td>The value must not exceed 4%</td>
<td>The value must not exceed 4%</td>
</tr>
<tr>
<td>5.7.1</td>
<td>Durability against freeze-thaw</td>
<td>Maximum allowable category MS18</td>
<td>Maximum allowable category MS18</td>
<td>Maximum allowable category MS18</td>
</tr>
<tr>
<td>5.7.3</td>
<td>Durability against alkali silica reactivity</td>
<td>Specified for aggregates produced from natural gravels</td>
<td>Specified for aggregates produced from natural gravels</td>
<td>Specified for aggregates produced from natural gravels</td>
</tr>
</tbody>
</table>

Note: (I) Coarse is the size greater than 4 mm

Sand and gravel will be kept in different stockpiles and in generally their mixture must be avoided. The stocks of both sand and gravel must be placed on inclined bases of lean concrete or of another surface approved by the Engineer so as to avoid contamination by soil and facilitate the drainage of the stock piles. Aggregates that have been placed direct on soil will not be used in concrete mixes.

The Engineer reserves the right to demand at any time from the Contractor to carry out laboratory test to verify whether the quality of the aggregates comply with the Norm EN 12620:2002.

The Engineer reserves the right to demand from the Contractor not to use aggregates that are not of his approval and to have them removed from the Site.

### 3.1.3 Water

The water used for the concrete mixing must be from clean water supply (potable). Non potable water may be used if it complies with EN1008:2002 “Mixing Water for Concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry as mixing water for concrete” or it is approved by the Engineer.

### 3.1.4 Additives - Admixtures

The concrete will compose of cement, aggregates and water as it is specified. No other substance will be mixed in the concrete or the mortar without the approval of the Engineer. The use of chlorides is prohibited.
The contractor may examine the use of natural pozzolans for the partial replacement of cement in the mix or alternatively the use of admixtures with hydraulic properties that will contain pozzolans and that in cases only of massive concretes.

These materials must conform to standards ASTM C618-73 and ASTM C595-75, respectively, and will be tested in combination with the cement and/or the aggregates used on site so as to prove their beneficial properties to the satisfaction of the Engineer before the contractor may gain approval for their use.

If the Engineer approves the use of additives, such as retarders or plasticizers that comply with standards EN 480:2006 “Admixtures for concrete, mortar and grout. Test Methods” and EN 934:2001 “Admixtures for concrete mortar and grout. Concrete admixtures. Definitions, requirements, conformity, marking and labeling”, their use will be subject to the following rules:

- The average strength of the tested specimen shall not be lower than the average strength of the tested specimen without the use of additives.
- The quantity of the cement shall not be reduced below the minimum limit described for the specific concrete category.
- International approved tests will be carried out to determine the time of solidification, the workability and the strength of the concrete mixes that contain additives.
- The amount of additives added as well as the mixing time must follow the instructions of the manufacturer of the products, adjusted to the existing conditions on site.

### 3.1.5 Concrete Quality

The concrete’s designed compressive strength and the size of aggregates used must comply with what is written on the drawings and the specifications.

The following concrete classes will be used: C15, C20, C25, and C30. The above mentioned concrete classes must satisfy the requirements presented in the following table 3.1-2.

It should be stated that wherever in the drawings concrete class C12/15 or C20/25 is written it is meant to be class C15 and C25 respectively.

<table>
<thead>
<tr>
<th>Table 3.1-2 Concrete class</th>
<th>Concrete class</th>
<th>C15</th>
<th>C20</th>
<th>C25</th>
<th>C30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Aggregate Size (mm)</td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Minimum Cement Quantity (kg/m³)</td>
<td></td>
<td>250</td>
<td>300</td>
<td>350</td>
<td>370</td>
</tr>
</tbody>
</table>
### 3. Structural Specification

<table>
<thead>
<tr>
<th>Concrete class</th>
<th>C15</th>
<th>C20</th>
<th>C25</th>
<th>C30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slump (mm)</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
</tr>
<tr>
<td>Maximum Water/Cement Ratio</td>
<td>0.60</td>
<td>0.55</td>
<td>0.55</td>
<td>0.55</td>
</tr>
<tr>
<td>Specified Strength of 150 mm cube specimens</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tested at 7 days (N/sq.mm)</td>
<td>10.0</td>
<td>13.5</td>
<td>16.5</td>
<td>20.0</td>
</tr>
<tr>
<td>Specified Strength of 150 mm cube specimens</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tested at 28 days (N/sq.mm)</td>
<td>15</td>
<td>20</td>
<td>25</td>
<td>30</td>
</tr>
<tr>
<td>Preliminary Laboratory- Strength of 150 mm cube specimens</td>
<td>13</td>
<td>18</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Tested at 7 days (N/sq.mm)*</td>
<td>(17)</td>
<td>(22)</td>
<td>(25)</td>
<td>(28)</td>
</tr>
<tr>
<td>Preliminary Laboratory Strength-of 150 mm cube specimens</td>
<td>20</td>
<td>27</td>
<td>32</td>
<td>37</td>
</tr>
<tr>
<td>Tested at 28 days (N/sq.mm)*</td>
<td>(25)</td>
<td>(33)</td>
<td>(38)</td>
<td>(43)</td>
</tr>
</tbody>
</table>

*The values in brackets refer to concrete not produced in plants producing ready-made concrete.

**NOTE:** The maximum cement content in any mix shall not exceed 500 kg/m³ for normal structures and 425 kg/m³ for liquid retaining structures.

#### 3.1.6 Mix design

For concrete mixes with specified strength equal or greater than 20 N/mm², the Contractor must submit a design mix report.

After the approval of the submitted design mix report, with the weight percentage of cement, water, sand and gravel clearly stated., the contractor shall perform 1÷3 trial mixes with the presence of the Engineer and following any orders the Engineer issues. From every trial mix two (2) to six (6) cube test samples (according to the Engineer’s instructions) will be taken to be tested for their compressive strength. ¼ of the taken cube test samples will be tested at 7 days for their strength and the rest samples at 28 days. The strength of each cube test sample tested at 28 days must be considerably higher than the specified strength. In the case that there are no previous data the average strength of the tested samples must be 3 N/mm² greater than the specified strength.

As soon as the Engineer approves the design mix and is satisfied by the trial mixes and the tests carried out then the contractor is prohibited from changing the source and quality of the supplied materials and the mix proportions without prior approval of the Engineer. If for any reason any of the above mentioned parameters are altered then the contractor is obliged to submit a new design mix for approval.
3.1.7 Predetermined Concrete Mixes

For concrete strength requirements of 15 N/mm² or lower strength ready-made mixes described in Table 3.1-3 can be used. The weight proportion per material indicated for the ready-made mixes can be used for the first mix and according to the results from the tests against compression they could be changed if required so.

Table 3.1-3   Predetermined Mixes

<table>
<thead>
<tr>
<th>Quality or Concrete Class</th>
<th>Maximum Aggregate Size (mm)*</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fluidity*</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Slump (mm)</td>
<td>0÷30</td>
<td>30÷60</td>
<td>60÷180</td>
<td>0÷30</td>
<td>30÷60</td>
<td>60÷180</td>
</tr>
<tr>
<td>C5 (W/C=0.7)</td>
<td>Minimum Cement Weight (kg)</td>
<td>-</td>
<td>180</td>
<td>200</td>
<td>200</td>
<td>210</td>
<td>230</td>
</tr>
<tr>
<td></td>
<td>Minimum Aggregates Weight (kg)</td>
<td>-</td>
<td>1995</td>
<td>1940</td>
<td>1995</td>
<td>1920</td>
<td>1800</td>
</tr>
<tr>
<td></td>
<td>Fine Coarse Aggregates (Sand) (%)</td>
<td>-</td>
<td>25÷50</td>
<td>25÷50</td>
<td>35÷55</td>
<td>35÷55</td>
<td>35÷55</td>
</tr>
<tr>
<td>C10 (W/C=0.65)</td>
<td>Minimum Cement Weight (Kg)</td>
<td>-</td>
<td>210</td>
<td>230</td>
<td>220</td>
<td>240</td>
<td>260</td>
</tr>
<tr>
<td></td>
<td>Minimum Aggregates Weight (kg)</td>
<td>-</td>
<td>1965</td>
<td>1925</td>
<td>1975</td>
<td>1890</td>
<td>1835</td>
</tr>
<tr>
<td></td>
<td>Fine Coarse Aggregates (Sand) (%)</td>
<td>-</td>
<td>25÷50</td>
<td>25÷50</td>
<td>35÷55</td>
<td>35÷55</td>
<td>35÷55</td>
</tr>
<tr>
<td>C15 (W/C=0.65)</td>
<td>Minimum Cement Weight (Kg)</td>
<td>235</td>
<td>270</td>
<td>290</td>
<td>255</td>
<td>300</td>
<td>320</td>
</tr>
<tr>
<td></td>
<td>Minimum Aggregates Weight (kg)</td>
<td>1995</td>
<td>1900</td>
<td>1850</td>
<td>1940</td>
<td>1820</td>
<td>1775</td>
</tr>
<tr>
<td></td>
<td>Fine Coarse Aggregates (Sand) (%)</td>
<td>25÷50</td>
<td>25÷50</td>
<td>25÷50</td>
<td>35÷55</td>
<td>35÷55</td>
<td>35÷55</td>
</tr>
</tbody>
</table>

*Specified by the Engineer

3.1.8 Concrete Testing

The verification of the concrete compressive strength shall be based on the crushing of 150mm cube test samples. The maximum cement content in any mix shall not exceed 500 kg/m³ for normal structures and 425 kg/m³ for liquid retaining structures. The Contractor must have on site a cone so as to perform slump tests and a necessary number of cube molds so as to be able to fulfill the sequence of tests listed below:
3. Structural Specification

- 1÷3 cube test samples from each mix if the volume of concrete is of the order of 4÷6 m³.
- 1÷2 cube test samples every 4 mixes if the volume of the concrete is of the order of 0.5 m³.
- 1÷2 cube test samples every 10 mixes if the volume of the concrete is smaller than 0.5 m³.

The Engineer may alter the sampling sequence according to the quality of concrete and the type of works it is going to be used. All test samples must be numbered.

A small number of test samples will be tested at 7 days (approximately ¼ of the total number of samples) and the rest at 28 days. The results from the specimens tested at 7 days will be treated as indicative.

The concrete will comply with the specifications when both of the following criteria are satisfied:

- The average strength of the cube test samples of 4 consecutive tests* crushed at 28 days must be greater than 3N/sq.mm for concrete categories C20 and greater than 2N/sq.mm for categories lower than C20.
- The strength of any test sample crushed at 28 days must not be smaller than 3N/sq.mm for concrete categories C20 and smaller than 2N/sq.mm for categories lower than C20.

*Every crushing of a cube specimen is considered as a test.

The Engineer may demand the testing of cylindrical test samples from the laboratory for more appropriate results. The tests of the cylindrical samples will be executed in accordance to EN 12350:2000 “Testing fresh concrete”, EN 12390:2000 “Testing hardened concrete”, EN 12504:2000 “Testing concrete in structures” and EN 13791:2007 “Assessment of in situ concrete compressive strength in structures or in precast concrete components”.

In the case where the strength criteria set by the specifications are not met, the Engineer retains the right to demand the demolition of the structures. The Contractor is responsible for the cost and the delays caused. The Contractor must take all necessary additional remedial measures for improving the concrete’s strength following the Engineer’s Orders before new concreting takes place.

The Contractor is obliged to keep full records regarding the concrete’s category, the concreting date and location and all relative data and results for the cube and cylindrical test samples. The records must be at the disposal of the Engineer at any time.

The equipment used for the concrete mixing must be appropriate and in good condition. The Engineer retains the right to prohibit the concrete mixing and demand the removal or
substitution of inappropriate equipment.

The sampling, transportation, storage, protection and testing of the cube test samples will be executed according to Standards EN 12350, 12390, 12504 and 13791. The concrete’s workability will also be checked according to these standards.

Table 3.1-4   Quality inspection of concrete and aggregates

<table>
<thead>
<tr>
<th>Test</th>
<th>Frequency</th>
<th>Testing location</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Sieve analysis</td>
<td>Twice a week, or every 300 m³ of concrete</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Bulk weight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Specific weight of aggregates, absorption test</td>
<td>At the beginning of each process or at the change of aggregates source</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Surface moisture content of fine aggregates</td>
<td>Once a day</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Los Angeles resistance to wear by abrasion and impact</td>
<td>Every 1,000 m³ of concrete</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Aggregates resistance to weathering (soundness)</td>
<td>Every 2,000 m³ of concrete</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Presence of harmful aggregates’ admixtures (friable particles, clay lumps, sand colorimetric test)</td>
<td>Every 2,000 m³ of concrete</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Potential harmfulness of aggregates during alkali-silica reaction, chemical method</td>
<td>Every 10,000 m³ of concrete</td>
<td>Aggregates storage area</td>
</tr>
<tr>
<td>- Concrete compression strength</td>
<td>Every 150 m³ of concrete or every concreting day; the lower value of the two applies</td>
<td>Concreting location</td>
</tr>
<tr>
<td>- Slump</td>
<td>Every concreting hour</td>
<td>Concreting location</td>
</tr>
<tr>
<td>- Measurement of the concreteand environment temperature</td>
<td>Every concreting hour</td>
<td>Concreting location</td>
</tr>
</tbody>
</table>

3.1.9 Concreting Records

The contractor is obliged to keep records regarding the concreting works. The specific record must be submitted every day to the Engineer for approval. The Engineer must note on the record the observations made on site and comments regarding the contractor’s schedule. The record must include notes and data for the following:
3. Structural Specification

- The names of the supervising engineers and their assistances assigned by the Contractor that will be involved during the specific concreting works.

- A description of the weather conditions, the temperature and the humidity. A list with the temperature of the water, the cement, the aggregates and the concrete itself must also be included.

- The invoices of the materials for the concrete mix on site delivered on site. (Quantities of materials, Cement brand name, etc.).

- Any specific instructions issued by the Engineer.

- The supervision by the Engineer.

- The time of starting and finishing the concreting works, mentioning also segments of implementation. The time of erection and removal of the formworks.

- The quantities of the cement, admixtures, fine and coarse aggregates and any additives used in every concreting work. The number of quality tests executed in the above mentioned materials and the water used.

3.1.10 Transportation

The transportation from the batching plant to the site may be done with delivery concrete truck carriers (rolled mixer) or any other appropriate mean indicated by the Engineer. In general the elapsing time between concrete mixing and pouring should not exceed 30 minutes. In case where retarding additives are used as specified in Paragraph 6.04 then the transportation time will be adjusted according to the instructions of the Engineer. During concrete casting, the concrete must have the predefined slump.

3.1.11 Concrete Casting

The Engineer must be present during concrete casting. Formwork and reinforcement must have been checked and approved according to drawings. In no case should the concrete be left to fall free from a height exceeding 1.5 m. In no case should the concrete be placed in stagnant or running water unless it is approved by the Engineer.

The concrete must be compacted by mechanical vibrators. The vibrators must be embedded well in the concrete mass and in appropriate distances that ensure adequate concrete compaction without voids. The vibrators must be slowly drawn out from the poured concrete after their embedment so as to avoid air voids.

If the concrete is poured in the formwork with the use of a pump this should be taken into account in the concrete mix design. The concrete may be richer in fine aggregates and
contain admixtures of the approval of the Engineer. The concrete must have a relative high slump (7÷12 cm).

3.1.12 Construction Joints

The concrete casting must be continuous till the completion of the scheduled works or till a pre-specified construction joint according to drawings. In case the concreting is stopped before a pre-specified construction joint the Engineer must be notified immediately for his approval and instructions. Before new casting takes place the hardened surface must be washed with water. Compressed air must be used to remove the previously applied water. The newly poured concrete must be placed near the hardened surface and vibrated adequately.

3.1.13 Concrete Curing after Casting

The concrete must be treated immediately after pouring so that it is protected from exposure to sun, wind, frost and rain. The concrete protection may be done with one of the following measures:

Covering the concrete surface with a saturated membrane. The membrane must be kept saturated for at least 7 days.

Covering the concrete surface with wet sand. The sand must be kept wet for at least 7 days.

Using different chemicals for concrete curing that have previously been approved by the Engineer.

3.1.14 Concreting Under Warm Weather

During warm weather the stockpiles of aggregates must be protected from solar radiation or watered. The water tank and distribution pipes must be insulated. The concrete’s temperature during pouring must not exceed 32°C.

The formwork surfaces and the reinforcement must be wetted before casting takes place so that water is not absorbed from the concrete. Immediately after pouring the concrete surfaces must be protected according to the provisions set by Paragraph 6.13.

3.1.15 Preparation of surfaces prior to concreting

Rock surfaces should be carefully cleaned with water and air under pressure just prior to
concreting. The water must be removed and the surface will be laid with mortar consisting of sand and cement. Only surfaces that will be concreted within half hour will be laid with the sand-cement mortar.

The surfaces at construction joints must be meticulously treated and loose aggregates should be removed from the top surface. The surfaces should be left undisturbed, clean without water, sand, loose materials etc. After concreting the hardened surface must be kept wet but without allowing the presence of stagnant water.

### 3.1.16 Reinforcement

The reinforcement shall consist of high or low tensile steel that conforms to Norms EN 10080:2005 “Steel for the reinforcement of concrete. Weldable reinforcing steel. General”, EU-8069 and EU-8085. The Engineer retains the right to demand from the Contractor to present certificates of quality control from the supplier. The steel bars bending shall be carried according to Norm 10080.

The reinforcement bars must be clean, free of impurities, dust, oil and paint. The reinforcement must be placed and mantled with precision according to the drawings. Where it is not specified the concrete cover is set to 50 mm.

The reinforcement lap length will be at least 50 times the diameter bars unless otherwise specified in the drawings.

The reinforcement must be supported adequately so as not to deform and be able to carry loads during concreting. In order to ensure the appropriate cover concrete, plastic or other spacers approved by the Engineer must be used.


### 3.1.17 Formworks

The formworks must comply with precision the shape, location, line and height required on site or specified in the drawings. The formworks must be supported adequately so as not to deform during concreting or compaction. The formwork joints must be watertight.

Top surface formworks must be used when concreting takes place on surface with inclination greater than 1:2.5.
Before the formwork is mounted it must be thoroughly checked and cleaned. The inner surface of the formworks must be oiled with special oil preferable before it is mounted and certainly before the reinforcement placement. The use of steel plates or small diameter reinforcement, embedded perpendicular in the concrete in order to facilitate the stability of the formwork, is prohibited. If this is required then special bolts and plastic tubes must be used or any other support method that in any case must have the prior approval of the Engineer.

Concrete casting is prohibited before the formwork and reinforcement are approved from the Engineer. The Engineer retains the right to demand, in certain cases (i.e. bridges), a calculation report proving the formwork/shuttering stability-rigidity. This report must be submitted 6 weeks before the scheduled concrete works. Although the Engineer issues the approval of the formwork/shuttering, its structural adequacy is full responsibility of the Contractor.

The Contractor is at all cases responsible for the stability of the formwork. The Contractor is responsible for all remedial works, compensations and time delays in case of accidents and unsatisfactory work due to inadequate formwork support.

The type of surface finishing of the concrete must comply with the one prescribed in the drawings, specifications or the Engineer instructions. All formwork joints shall be either vertical or horizontal as per the agreed pattern. Any holes serving support or spacing purposes shall be sealed with plastic covers or cement mortar identical to the poured concrete following the Engineer’s orders. The Engineer reserves the right to demand the placement of trowels, water cut offs or whatever is required to achieve the required result.

The removal of the formwork must be carried carefully without causing damage to the concrete. The time for the formwork removal will be proposed by the Contractor and approved by the Engineer. The Contractor must take into account the type of cement used, the admixtures/additives added and the weather conditions. The indicative table (Table 3.1-5) listed below provides formwork removal time for normal structures and weather conditions.

Prior to the removal of the formwork, the Engineer must be notified well in advance. After the formwork removal no part of reinforcement must be visible. In the contrary, remedial works of the Engineer’s approval must be carried. All costs regarding remedial works or even partial demolition will be covered by the Contractor.

<table>
<thead>
<tr>
<th>Table 3.1-5</th>
<th>Time for Formwork Removal Formwork</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Formwork</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Slab Formwork (deck)</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Columns for slabs, beams and frames</td>
<td>21-28</td>
<td></td>
</tr>
<tr>
<td>Columns under Cantilevers</td>
<td>28</td>
<td></td>
</tr>
</tbody>
</table>
3. Structural Specification

3.1.18 Formed Surfaces

Unless otherwise specified in the drawings, the formwork surfaces must comply with one of the following classes listed below:

Class F1:
It refers to cases where the concrete surfaces will be backfilled or covered with concrete. The formwork surface must be such that the loss of any of the concrete components is prohibited and allows for a compact top surface.

Class F2:
It refers to cases where the concrete surface will be permanently exposed unless otherwise specified in the drawings. The formwork surface must be such that the loss of any of the concrete components is prohibited and a durable lean surface is formed without discontinuities, cavities, etc. Although cavities are prohibited, small imperfections can be repaired with techniques and materials approved by the Engineer.

Class F3:
It refers to cases where the concrete surfaces will be in contact with water flow of specific requirements (high velocities, cavitation risk, etc.). The formwork surfaces must be such that a lean straight surface correctly aligned vertically and horizontally is achieved free of cavities and humps. The Engineer retains the right to demand the plastering of the surfaces with the appropriate mortar mix so as to achieve the desirable surface finish.

When a surface is partially backfilled and exposed then the surface finish of the exposed surface must extend 500 mm to the backfill.

3.1.19 Unformed Surfaces

Unless otherwise specified in the drawings the finishing of surfaces concreted without the use of formwork must comply with one of the finish classes listed below:

Class U1 (Screeded Surface):
It refers to road pavement, foundations slabs or other structural elements backfilled or road pavement that do not require better surface finish. This surface finish is a prerequisite for surfaces with a higher quality final finish such as class U2 and U3. The screeded finish will be achieved by hand sawing motion using a straight-edge timber of 50 mm thickness.

Class U2 (Floated Surface):
It refers to all exposed surfaces of permanent works unless otherwise specified in the drawings. The floated surface will be achieved by wood or bull float so as to allow
abundance of fine aggregates on the top surface.

**Class U3 (Trowelled Surface):**

This class refers to all surfaces that will be subject to contact with water flow of specific requirements (high velocities, cavitation risk etc.). Surfaces finishing of class U1 and U2 must have already been implemented. Manual or mechanical steel trowelling must be applied on the floated surface after the concrete has sufficiently hardened. If required a custom made cover must be applied to protect the final surface from rain.

### 3.1.20 Acceptance Tolerances of Concrete Surfaces

The abnormalities observed for the different classes of the formed and the unformed surfaces must be within the limits set by table 3.1-6. If the abnormalities exceed the pre-specified limits, the Engineer will issue orders so that this does not re-occur. If the abnormalities exceed the maximum pre-specified tolerances limits, the Engineer retains the right to reject totally or partially the executed works.

In Table 3.1-6 the number in the brackets under the type of abnormality refers to:

- The element dimensions (walls, columns, beams, etc.) where for construction purposes the deviation must be kept to the allowable tolerances specified for the alignment and levels.
- Consecutive abnormalities created from the wrong formwork alignment and dimensions that are specified in the drawings and are measured with a 3 m long trowel.
- Abrupt changes in the surface created from the formwork/shuttering wrong placement, loss of support and defective equipment or uneven surface in case of unformed shapes.

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>Type of Final Shape</th>
<th>Formed Surface</th>
<th>Unformed Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Allowable Tolerance</td>
<td>Maximum Limit</td>
</tr>
</tbody>
</table>
| Deviation from the alignment and levels specified in the drawings | F1 F2 F3 F1 F2 F3 U1 U2 U3 | +20 -5 ±5 | +25 -10 ±10 | ±5 | ±3 | ±10 | ±5 | ±5

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3. Structural Specification

<table>
<thead>
<tr>
<th>Abnormality</th>
<th>Formed Surface</th>
<th>Unformed Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Allowable</td>
<td>Maximum Limit</td>
</tr>
<tr>
<td></td>
<td>Tolerance</td>
<td></td>
</tr>
<tr>
<td>F1</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>F2</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>F3</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>U1</td>
<td>-5</td>
<td>-5</td>
</tr>
<tr>
<td>U2</td>
<td>-3</td>
<td>-3</td>
</tr>
<tr>
<td>U3</td>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>

3.1.21 Ready Made Concrete Mix

The Ready Made Concrete Mix will be transported from the Concrete Plant to the site with concrete mixer trucks or other appropriate vehicles approved by the Engineer. During the transport the mixer must be rotating continuously so as to avoid concrete segregation. The mixing speed during transport and haulage must be set at the specified limits. In generally the transport time (starting from loading the truck mixer and ending with the delivery on the site) shall not exceed 30 minutes. In case where retarding additives are used, then the transportation time will be adjusted according to the instructions of the Engineer. During concrete casting, the concrete must have the predefined slump. The loading time must be written on the Concrete’s Delivery Invoice. Loading time starts when the cement is added on the aggregates.

Addition of water in the concrete mix is strictly prohibited during transport. When mixing takes place in truck mixers, then any water added at the batching plant or at site will be done under the supervision of an experienced and authorized technician.

With the approval of the Engineer ready mixed concrete may be used. The ready mixed concrete must comply with Norm EN 206-1:2000 “Concrete. Specification, performance, production and conformity” and Norm EN 12620:2002.

3.1.22 Pneumatically applied Concrete

Pneumatically applied mortar or concrete, designated herein as gunite or approved equal, shall consist of premixed sand and portland cement pneumatically transported in a dry state to a nozzle where hydration takes place immediately prior to expulsion (references ASTM C39 and C42)
3.1.22.1 Equipment

The cement gun should be operated at a minimum air pressure of 45 pounds per square inch on the gun tank when 100 feet or less of material hose is used, and the pressure should be increased 5 pounds for each additional 50 feet of hose required. Nozzles used for applying the material shall have a maximum size of 1 5/8 inches unless otherwise permitted by the Engineer.

Water used for hydration shall be maintained at a uniform pressure, which shall be at least 15 pounds per square inch above air pressure at the gun.

3.1.23 Proportions and mixing

Unless otherwise specified, the material shall consist of a mixture of cement and sand in the proportions, by volume, of 1 part of cement to 4 1/2 parts sand. The sand and cement shall be thoroughly mixed in a power mixer for at least 1 1/2 minutes before placement in the chamber of the gun. The dry mixed material shall be used promptly after mixing, and any material that has been mixed for more than 45 minutes shall be wasted.

3.1.23.1 Tests

During the application of the material, the Contractor shall cooperate with the Engineer in making compressive tests required to determine the quality of the material being placed in the work. The tests shall be conducted in conformity with the requirements of ASTM C 39. Test specimens shall be made so as to represent the quality of material being placed in the work by each nozzle man and shall consist of 6 inches x 12 inches cylinders made by shooting the material vertically into cylindrical cages of 1/2 inch mesh hardware cloth mounted on a board. The material outside the mold should be removed immediately after shooting the specimen so that the wire mesh can be detached before testing. The number of test specimens to be taken shall be as provided in the Supplementary Specifications or as determined by the Engineer. Separate test specimens made at the same place and time shall be tested at the age of 7 and 28 days. The specimens at the age of 7 days shall develop a minimum compressive strength of 2,400 pounds per square inch, and at the age of 28 days the specimens shall develop a minimum compressive strength of 3,500 pounds per square inch unless otherwise specified herein. In lieu of the above tests, the Engineer ay elect to perform core tests. A minimum of 3 cores shall be taken for each 250 cubic yards or fraction thereof of material deposited.

Cores shall be obtained and tested in accordance with ASTM C 42. One core shall be removed and tested at an age of 14 days, the other 2 cores at an age of 28 days. Fourteen day cores shall develop a minimum strength of 2,200 psi. Twenty-eight day cores shall develop a minimum strength of 3,000 psi unless otherwise specified herein.
If the cores show deficient strength, additional cores shall be taken at the Contractor's expense from adjacent areas. Two cores shall be required for each deficient core. Should such deficiency be evident in 14 day cores, on approval of the Engineer, the Contractor may proceed with the work on his own responsibility until the 28 day cores are tested.

Where conditions preclude the possibility of obtaining cores from the material in place, the Engineer may approve cores taken from a representative test panel made at the same time and under the same conditions as the material being placed in the work.

3.1.23.2 Placement

Earth surfaces to which the material is to be applied shall be neatly trimmed to line and grade and shall be free of all loose material. The surface need not be compacted by slope rolling or other measures unless required by the plans or Supplementary Specifications.

No high subgrade will be permitted and excavation made below subgrade shall be backfilled with compacted fill or, at the Contractor's option, with the material. However, no additional compensation will be allowed for such compacted fill nor for increased thickness of material placed on account of low subgrade.

Asphaltic concrete surfaces shall be thoroughly cleaned of any growth, silt and clay, or any other material detrimental to the material and then washed with water under pressure.

Masonry, rock, and concrete surfaces shall be examined and all loose material removed there from. The surface shall be thoroughly cleaned with steel scrapers or brushes to remove all dust, dirt, mortar, grease, or other deleterious substances and then washed with water.

Whenever brushing and scraping do not secure suitable results, sandblasting may be required.

All surfaces shall be wetted with water before application of the material, and no material shall be applied to surfaces on which free water exists.

The velocity of the material as it leaves the nozzle shall be maintained uniformly at a rate determined for given job conditions. Material which rebounds and does not fall clear of the work or which collects on the surfaces shall be blown off or otherwise removed. Rebound shall not be used in any portion of the work, and no pavement will be incorporated for rebound or other losses.

The nozzle shall be held at such distance and position that the stream of flowing material will impinge at approximately right angles to the surface being covered. Any portions of the placed material which tend to sag or which show soft or sandy pockets or are otherwise unsatisfactory shall be cut out and replaced. Reinforcement thus damaged or destroyed shall be replaced by trimming back and properly lapping and tying, to the satisfaction of the
Reinforcement shall be firmly supported in the position shown on the plans. Mortar blocks, metal chairs, clips, or spacers with wire ties or other acceptable means shall be used to properly anchor and place the reinforcement.

Where material is placed on overhead surfaces, the amount of water used shall be so adjusted that approximately 3/4 inch of the placed material shall adhere without support. The limit of thickness has been exceeded when the material begins to sag or slough.

3.1.23.3 Forms and ground wires

The forms shall be built in accordance with applicable provisions of the specifications, except all forms shall be built so as to permit the escape of air and rebound.

Ground wires shall be installed in such manner that they accurately outline the finished surface as indicated on the plans. They shall be located at intervals sufficient to insure proper thickness throughout. Wires shall be stretched tight and shall not be removed prior to application of the finished coat.

Headers will be required where the plans indicate a formed edge and at plan joints.

3.1.23.4 Joints

Construction joints shall be sloped off at an angle of approximately 45° to the surface being shot. Before shooting the adjacent sections, the sloped portion shall be thoroughly cleaned and wetted by means of air and water blast. The plan joint shall be formed in accordance with and placed in the locations as designated on the plans.

3.1.23.5 Finish

Upon reaching the thickness and shape outlined by forms and ground wire, the surface shall be rodded off to true lines. Any low spots or depressions shall be brought up to proper grade by placing additional material. Ground wires shall then be removed; and unless otherwise specified, the surface shall then be broom finished to secure a uniform surface texture.

Rodding and working with a wood float shall be held to a minimum. Rebound or accumulated loose sand shall be thoroughly cleaned up and disposed of to the satisfaction of the Engineer. In no case shall it be floated into the surface of the work. When a nozzle finish is specified on the plans, ground wires shall not be used and the surface shall be left as uniform as possible without rodding. Nozzle finishes will not be permitted where the underlay has been floated.
3.2 JOINTS, JOINT SEALERS AND BEARINGS

3.2.1 Water-stops – General

The Contractor shall supply and fix water-stops in all contraction and expansion joints in structures which are to be water retaining and where shown on the Drawings. Such joints shall be watertight.

Water-stops unless otherwise specified shall be of rubber as shown on the Drawings. They shall be obtained from manufacturers approved by the Engineer and shall be stored, fixed and jointed in accordance with the manufacturer’s instructions. They shall be fabricated into the longest practicable units complete with angles and junctions, at the manufacturer’s plant, and shall be made continuous throughout the structure and above the highest water level and where it is shown on the Drawings. The Contractor’s proposals for jointing water-stops on Site shall be to the approval of the Engineer. Rubber water stops shall be jointed with an approved sleeve jointing system.

The minimum dimensions and shape of water-stop types shall be as tabulated below:

<table>
<thead>
<tr>
<th>Table 3.2-1 minimum dimensions and shape of water-stop types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Material</strong></td>
</tr>
<tr>
<td>---------------</td>
</tr>
<tr>
<td>Rubber</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

The edge bulb section shall be circular. The webs shall be plain without serrations.

The water-stop shall be carefully maintained in the position shown on the Drawings and properly protected from damage and the harmful effects of light and heat during all stages of construction. The stop-boards on each side of the water-stop shall be accurately wrought to match the profile of the water-stop. The concrete shall be carefully compacted under and around the water-stop so as to leave no cavities.

The Contractor shall supply the manufacturer’s test certificates for each consignment of water-stop delivered to Site, and shall, if requested, supply to the Engineer sufficient of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.

3.2.2 Rubber Water-stop

The rubber for rubber water-stop shall satisfy the following requirements when tested as
moulded sheet in accordance with BS 903-5:2004 “Physical testing of rubber. Guide to the application of rubber testing to finite element analysis” and ISO 815:1991 “Rubber, vulcanized or thermoplastic – Determination of compression set at ambient, elevated or low temperatures”.

- **Minimum tensile strength**: 20 N/mm² (204 kg/cm²)
- **Minimum elongation at break**: 500%
- **Hardness**: 60 to 65 degrees
- **Maximum compression set by constant deflection method**: 20% of original deflection
- **Maximum water absorption after 2 days at 20°C**: 5%
- **After accelerating ageing (48 hours at 70°C in oxygen at 2.0 N/mm² (20 kg/cm²)**
  - **Minimum tensile strength**: 75% of initial value
  - **Minimum elongation at break**: 75% of initial value

Rubber water stops shall be installed as shown in the drawings or according to the guidelines of the Engineer.

### 3.2.3 Stainless Steel Water stop

The Contractor should supply and place stainless steel water stops as indicated in drawings or following the instructions of the Engineer. The stainless steel water stops will follow the below requirements unless otherwise is instructed by the Engineer with an official letter.

The width of the stainless steel water-stop should be 23cm and 30cm and will be according to ASTM A-167, Class 6, condition A (unnealed) finished with hot or cold extrusion and width No20 based on US standards.

Stainless steel water-stop shall satisfy the following requirements when tested in accordance with ASTM A 240 — Test Method for Stainless Steel Physical Properties. The Contractor shall submit for approval the following for each shield:

- Samples of each size and shape to be used.
- Plate drawings of the waterstop profile indicating all dimensions.
- Shop drawings of shop made fittings to be provided by the manufacturer or prepared by the contractor.
- Sample field lap splice to be furnished with shipment.
- Manufacturer’s Literature, including MSDS sheets, installation instructions and splicing instructions.
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- Certificate of compliance to physical properties outlined in this specification using ASTM A 240 test method.

Stainless Steel Waterstop shall conform to the following minimum physical properties:

**Table 3.2-2 minimum physical properties**

<table>
<thead>
<tr>
<th>Property</th>
<th>Test Method</th>
<th>Required Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile Strength</td>
<td>ASTM A 240</td>
<td>70,000 psi</td>
</tr>
<tr>
<td>Elongation in 2” minimum</td>
<td>ASTM A 240</td>
<td>40%</td>
</tr>
<tr>
<td>Yield Strength</td>
<td>ASTM A 240</td>
<td>25,000 psi</td>
</tr>
<tr>
<td>Rockwell B Hardness</td>
<td>ASTM A 240</td>
<td>95</td>
</tr>
</tbody>
</table>

Material delivered and placed in storage shall be stored off the ground and protected from moisture, dirt, and other contaminants.

### 3.2.3.1 Execution

Waterstops shall be installed at the locations shown on drawings to form a continuous fluid-tight diaphragm. Adequate provision shall be made to support and completely protect the waterstops during the progress of the work. Exposed waterstops shall be protected during application of form release agents to avoid being coated. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded waterstops from damage when concrete placement has been discontinued. Splices shall be made by certified, trained personnel using approved equipment and procedures.

Stainless steel water stops shall be welded or bronze-welded with the respective bars. The Contractor will provide all the necessary information for the welding in order to be approved by the Engineer. The water stops will be welded carefully in a way to provide a continuously waterproof diaphragm to the joint. The two welded parts shall overlap a minimum of 15mm and the weld shall cover the entire width edge-to-edge of the water stop. The damaged waterstops shall be repaired by removing damaged portions and patching. Patches shall overlap a minimum of 15mm onto undamaged portion of the waterstop.

**Preparation**

- Position waterstop to ensure proper distance from steel reinforcing bars to prevent rock pockets and honey comb.
- Protect waterstop from damage during progress of work.
- Clean concrete joint after first pour to remove debris and dirt.
Examination/Inspection

- Prior to placement of concrete notify engineer for field inspection approval.
- Upon inspection of waterstop installation, replace any damaged or unacceptable waterstop and dispose of defective material.

Installation

- Position waterstop in joint as indicated on drawings.
- Center waterstop on joint, with approximately one-half of waterstop width to be embedded in concrete on each side of the joint.
- Allow clearance between waterstop and reinforcing steel of a minimum two times the largest aggregate size. Prevent rock pockets and air voids caused by aggregate bridging.
- Carefully place concrete without displacing waterstop from proper position.
- Thoroughly and systematically vibrate concrete in the vicinity of the joint, and to maximize intimate contact between concrete and waterstop.

- After first pour, clean unembedded waterstop leg to ensure full contact of second concrete pour. Remove laitance, spillage, form oil and dirt.

3.2.4 Joint Fillers – General

The Contractor shall supply and fix joint fillers in movement joints only where shown on the Drawings. Unless otherwise specified the joint filler shall be of impregnated fibreboard or resin bonded cork. It shall be obtained from manufacturers approved by the Engineer and shall be stored and fixed in accordance with the manufacturer’s instructions. The joint filler of the material and thickness specified, shall be cut to shape and fixed to fill the whole space between the concrete faces to the joint not otherwise filled by water-stop and joint sealer. Abutting pieces shall be placed in close contact and the joints covered on each side to prevent the passage of cement grout.

The Contractor shall supply the manufacturer’s test certificate for each consignment of each type of joint filler delivered to Site and shall, if requested, supply to the Engineer sufficient of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate standard test procedure.
3.2.5 Cork Filler

The resin-bonded cork filler shall comply with United States Federal Specification HH-F-341 Type II Class B (and ASTM D1751-04 “Standard specification for performed joint filler for concrete paving and structural construction”) with the following limitations when tested in accordance with the above Specification:

- The load required to compress the material to 50% of its thickness shall be more than 0.035 N/mm² and less than 0.35 N/mm².
- The recovery after compression to 50% of the original thickness shall be to not less than 95% of the original thickness.

3.2.6 Impregnated Fibreboard Filler

The impregnated fibreboard filler shall comply with the American Association of State Highways Officials (AASHO) Standard Specification M.153-54, or the United States Federal Specification HH-F-341 for Type 1 (and ASTM D1751-04 “Standard specification for performed joint filler for concrete paving and structural construction”), and with the limitation that the load necessary to compress the material to 50% of its thickness in the specified compression test shall be more than 0.035 N/mm² and less than 0.35 N/mm².

3.2.7 Dowel Bars

Where dowel bars are to be provided through movement joints the part of the bar to be free to move shall be coated with bitumen and fitted with a compressible cap of material as specified for impregnated fibreboard joint filler or other materials approved by the Engineer.

3.2.8 Joint Sealers, General

The Contractor shall construct recesses for joint sealers where ordered at movement joints. The recesses shall be accurately formed to the lines and dimensions shown on the Drawings or ordered by the Engineer.

The Contractor shall prepare the surfaces of the recess and shall supply a joint sealer and fill or caulk the recess completely with it. The joint sealer shall be either a polysulphide or a bituminous based compound. It shall be approved by the Engineer before ordering and shall be used in accordance with the manufacturer’s instructions, inclusive of the supply and application of any priming materials or bond breakers. The application of joint sealer shall not be commenced without the Contractor having first obtained the approval of the Engineer.

The Contractor shall supply the manufacturer's tests certificate for each consignment of
each type of joint sealer delivered to Site and shall, if requested, supply to the Engineer sufficient samples of each type and consignment for confirmatory tests to be carried out in accordance with the appropriate test procedure.

**3.2.9 Polysulphide Sealer**


**3.2.10 Bitumen-coated Joints**

Where the Drawings show contraction joint, bituminous paint will be performed between concrete faces and before casting adjacent concrete. The Contractor shall clean and dry the face to which the bitumen is to be applied and shall then paint the bitumen in two separate applications. The bitumen shall be a straight run bitumen, Grade 40/50 penetration, or other approved by the Engineer.

**3.3 PIPEWORK**

**3.3.1 Concrete Pipes**

Concrete pipes and fittings shall comply with EN 1916:2002 “Concrete pipes and fittings, unreinforced, steel fibre and reinforced” and BS 5911 “Concrete pipes and ancillary concrete products. Specifications for unreinforced concrete and reinforced concrete pipes (incl. jacking pipes) and fittings with flexible joints”. No admixtures shall be included in the concrete without the written approval of the Engineer.

Joints shall be spigot and socket type made with cement mortar, composed of one part Portland cement to one part fine sand, thoroughly packed into the joint with the appropriate tools.

**3.3.2 PVC Pipes**

uPVC pipes and fittings shall comply with EN 1452:2000 “Plastic piping systems for water supply. Unplasticised poly (vinyl chloride) (PVC-U). General”. Joints shall be of the spigot and socket type. The nominal pressure shall be PN 10 bar and 16 bar.

The material used in the manufacture of pipes, joints and fittings shall consist substantially of
polyvinyl chloride, to which may be added only those additives that are needed to facilitate the manufacture of the polymer and the production of sound and durable pipes of good surface, finish, mechanical strength and opacity. None of these additives shall be used separately or together in quantities sufficient to constitute a toxic hazard, to impair the fabrication or welding properties of the pipes, or to impair the chemical and physical properties of the pipes (in particular long term mechanical and impact strength). PVC content of the pipe shall not be less than 85% and the content shall be achieved by the use of process control method. No rework material shall be used and the dispersion of all ingredients in the material composition shall be uniform. When tested by method 120B of BS 2782 (Methods of Testing Plastics), the deformation temperature of the material under load shall not be lower than 75°C.

- EN 1452-2 Plastics piping systems for water supply - Unplasticized polyvinyl chloride (PVC-U) - Part 2: Pipes.
- EN 1452-3 Plastics piping systems for water supply - Unplasticized polyvinyl chloride (PVC-U) - Part 3: Fittings.
- EN 12842:2000 Ductile iron fittings for PVC-U or PE piping systems - Requirements and test methods
- EN 921:1994 Plastics piping systems - Thermoplastics pipes - Determination of resistance to internal pressure at constant temperature.
- EN 744:1995 Plastics piping and ducting systems - Thermoplastics pipes - Test method for resistance to external blows by the round-the-clock method.
- DIN 8061: uPVC pipes – Quality requirements - Testing
- DIN 8062: uPVC pipes – Dimensions
- DIN 8063: Joints and fittings for uPVC pipes – Bents and dimensions.
- DIN 16450: Special fitting for uPVC pipes
3.3.3 Steel Pipes


Pipes shall be of grade ST 37,2 according to DIN 17100 (S235JRG2 – EN 10125) and to EN 10027-1:2005 “Designation system for steels. Steel names”.

The pipes according to their diameter shall be manufactured by Electric Resistance Welded (E.R.W.) process or Sub Arc Spiral Welded (S.A.W.) process according to ISO 2604 Part 2 - TS9 Cat.II and ISO 2604 Part 6 - TSAW 9 Cat VI.

Pipe diameters and pipe wall thicknesses are defined in the drawings and other Tender Documents and shall comply with BS EN 534 “Specification for steel pipes, joints and specials for water and sewage”, DIN 1626/2458 and AWWA C200 “Steel water pipe 6” (150 mm) and longer”.

External and internal corrosion protection shall be of coal tar enamel coats according to the requirements of AWWA C203:2002 “Coal Tar Protective Coatings and Linings for Steel Water pipelines - Enamel and Tape - Hot applied” and BS 4164:2002 “Specification for coal-tar-based hot-applied coating materials for protecting iron and steel, including a suitable primer”.

Alternative external coatings of polyethylene or polypropylene wrapping, or thermosetting fusion bonded dry powder epoxy coating will be required if stated elsewhere in the Contract or requested by the Engineer.

Also alternative internal corrosion protection shall be of concrete or cement mortar if stated elsewhere in the Contract or requested by the Engineer.

3.3.4 HDPE Pipes

High Density Polyethylene (HDPE) pipes shall be made from polyethylene resin compound qualified for PE 100, Minimum Required Strength (MRS) 10 MPa and hydrostatic design stress $\sigma$ 8.0 MPa. The Standard Dimension Ratio shall be SDR 17 and the nominal pressure PN 10 bar.

High Density Polyethylene (HDPE) Pipes and fittings shall comply with the listed Standards or equivalent:

- EN 12201:2003 “Plastics piping systems for water supply - Polyethylene (PE)”
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- DIN 8074 “Polyethylene (PE) Pipes Dimensions”
- DIN 8075 “Polyethylene (PE) Pipes General Quality Requirements and Testing”
- DIN 19533 “PE HD/LD pressure pipes for water supply, requirements”
- DIN 16963 “Pipe Joint Assemblies and Fittings for High - Density Polyethylene (PE-HD) Pressure Pipes”
- EN 13244:2002 “Plastics piping systems for buried and above-ground pressure systems for water for general purposes, drainage and sewerage. Polyethylene (PE)”.

3.3.5 Setting Out

The Contractor shall, in the presence of the Engineer’s Representative, set out the pipeline alignments in accordance with the Drawings and making any changes the Engineer’s Representative may deem necessary. The Engineer will confirm also the exact locations of all manholes, valves, air valves, washouts, etc.

The Contractor shall then submit to the Engineer, at an approved scale, profiles of ground levels, showing the proposed invert levels and the precise location of all manholes, air valves, washouts, etc., for the Engineer’s approval.

The Contractor shall then supply to the Engineer two further copies of the approved profiles, incorporating all the pipeline details and all amendments required by the Engineer, before excavation of the pipelines commences.

3.3.6 Handling and Transport of Pipes and Fittings

The loading, unloading and handling of pipes and fittings shall be carried out using ropes, cranes, lifting beams and slings of approved design, strictly in accordance with the recommendations of the manufacturer and to the approval of the Engineer. Particular care shall be taken at all times to avoid damage of any kind. The use of lifting hooks is not permitted, except when used with protection which has been approved by the Engineer.

Where required internal support shall be provided to all pipes exceeding 800 mm diameter to prevent excessive deformation during handling, transport and storage.

The protective cover, discs, etc. provided by the manufacturer shall not be permanently removed until immediately prior to installation.

When pipes are loaded for road transport, they shall be at all times laid on suitably shaped padded cradles to prevent damage to the coating. When more than one tier of pipes is transported intermediate cradles shall be used. Pillows shall be provided between lashing
(ropes, wires or chains, etc.) and the pipes. All cradles and lashings shall be of such widths so as to prevent damage to the coating of the pipe or distortion of the pipes.

All valves shall be handled with care and shall always be transported on timber packing and where possible in the manufacturer’s original packing if this is suitable.

In the event of any damage being caused, the Contractor shall be liable for the cost of all repairs or replacements and the costs of any delays. The Engineer shall determine whether the damage shall be repaired and if it is to be repaired the manner of such repair, or whether the damaged piece shall be replaced.

3.3.7 Storage of Pipes and Fittings

The Contractor shall only store pipes, fittings and other materials at places approved by the Engineer and shall at all times provide adequate supervision to prevent theft or damage. Any damage incurred due to lack of such supervision or protection, will be the Contractor’s responsibility.

Pipes shall not be stacked in storage areas higher than recommended by the manufacturer. The area on which the pipes are to be stacked shall be free draining, the grass or other vegetation shall be kept cut and suitable timber or cradles shall be provided on which the pipes shall be laid. End stops to all stacks shall also be provided.

Fittings and valves shall not be stacked more than one tier high and they shall be supported off the ground by suitable timbers.

Air valves, rubber joint rings, gaskets, bolts and similar fittings and materials shall be kept in approved locked premises and such fittings and materials shall not be distributed to the trench side until immediately prior to laying, fitting, jointing or assembly thereof. All rubber joint rings and gaskets must be stored in a cool damp location and all fittings and materials shall at all times be stored in the shade, under cover and protected from the weather to the satisfaction of the Engineer’s Representative.

The Contractor shall take any necessary precautions to prevent fire in the storage areas and shall provide and maintain fire precautions.

3.3.8 Stringing of Pipes

Pipes shall be handled and transported in accordance with the Clause 9.06. Protective covering shall not be removed until pipes are to be inspected and laid. Where pipes, fittings or any other materials are laid out on the site adequate personnel shall be provided as required in Clause 9.07.
3. Structural Specification

Pipes shall be laid on suitable pillows or other supports approved by the Engineer.

At places where the pipeline route cross roads, tracks or any other access, and where directed by the Engineer, the Contractor shall deposit the pipes so that access to the public is not in any way prohibited. Where the pipeline crosses any field or other place frequented by people or livestock, similar provision shall be made.

The Contractor may be prohibited from using certain roads and other tracks for the purpose of stringing on account of adverse weather conditions. No extra cost he may incur on this account or for any other road restriction, delay, or any other matter which increases the cost of his haulage will be allowed. Such restrictions may be imposed due to dust in dry weather, as well as to road damage due to wet weather.

3.3.9 Examination of Pipes Prior to Laying

Shortly before laying or fixing any valve, pipe or fitting the Contractor shall in the presence of the Engineer’s Representative carefully examine each valve, pipe and fitting to ascertain damage or defect. All damage and all defects revealed by this examination shall be repaired and remedied to the satisfaction of the Engineer’s Representative.

The Contractor shall give the Engineer’s Representative not less than 48 hours' notice of his intention to examine any pipes, etc and the Contractor shall not proceed to lay such pipes until they have been approved as free from damage and defects by the Engineer’s Representative.

The ends of pipes and fittings shall be examined for circularity. Any distorted ends shall be corrected by an approved method to within the tolerances required by the mechanical couplings or other joints by which the pipes or fittings are to be jointed.

All pipes and fittings which are severely dented or similarly damaged shall be discarded unless in the opinion of the Engineer a portion of such pipe or fitting may usefully be salvaged in which case the Contractor may cut off and discard the damaged portion only.

After examination and any necessary repairs and attention, all pipes, fittings, etc. shall be cleaned internally, particular care being taken to ensure that no stones, etc. are bedded in bitumen linings.

3.3.10 Laying Pipes

Immediately before any pipe is lowered into the trench, the plug to be provided in accordance with this clause shall be removed from the end of the last pipe laid and the new pipe shall be carefully lowered into the trench with a crane or gantry operating within its designed working load or by other approved manner.
Each pipe and fitting shall be laid gently on the bedding so as not to damage the outer surface. Pipes shall be laid true to alignment curve and gradient, in accordance with the Drawings or as directed by the Engineer’s Representative.

Pipes shall be boned to gradient and sight rails shall be provided for this purpose at intervals not exceeding 50 m and at all changes in grade.

No dips or summits will be permitted other than shown on the Drawings unless otherwise instructed by the Engineer’s Representative.

Pipes and fittings laid in trench shall have the minimum cover stated on the Drawings or as otherwise directed by the Engineer’s Representative.

Pipes laid in trenches shall be laid and firmly bedded on an even and uniform bed. Where pipes are not laid on a granular bed, the bottom of the trench shall be smooth and free from stones or other projections. Pipes shall not be dragged along the trench bottom. Joint holes shall be excavated below the trench bottom, shall be as small as possible, shall be filled in and compacted after the pipes are laid and before the refilling of the trench is commenced. Survey pegs in the trench bottom shall be removed.

Ovality in pipes shall be removed by internal jacking methods to the approval of the Engineer. Pipes with ovality outside the manufacturer’s permitted values shall not be used.

Each type of joint shall be made in full compliance with the manufacturer’s instructions. Special care shall be taken to ensure the absolute cleanliness of the pipe ends and joint components.

Pipe jointing shall be carried out only by experienced personnel and with close supervision by the Contractor. Further pipe jointing shall not proceed until the previous joint has been inspected by the Engineer’s Representative or his assistant.

The Contractor shall take all steps necessary to ensure that no dirty water or other extraneous matter is allowed to enter the pipes during or after laying. In the event of dirty water or extraneous matter entering the pipes, the Contractor shall immediately carry out the necessary cleaning as may be directed by the Engineer’s Representative. No extra payment will be made or allowed for such work.

As pipe laying proceeds, the Contractor shall prove pipelines are free from obstruction by passing through the pipeline a “badger” which must be kept in the pipes at all times during construction of the pipelines. The “badger” shall be pulled forward and any obstructions or dirt removed immediately after the laying of each pipe and before the next one is placed in position, so that the barrel of the pipe is left perfectly clean.

The “badger” shall consist of polyurethane foam with dimensions approved by the Engineer, with suitable attachments to allow for pulling through the pipes.

Except when necessary for jointing, the end of the last pipe laid shall be plugged to the
satisfaction of the Engineer’s Representative and the Contractor shall provide and use a sufficient number of proper plugs for this purpose.

Any damage to the external surface and/or coating or to the internal surface and/or lining of pipes, fittings, etc. or to sleeving sustained during laying shall be repaired and made good to the satisfaction of the Engineer’s Representative who shall be afforded facilities of examining and testing any damaged areas of sheathing, coating, lining and sleeving.

Pipe trenches shall not be backfilled, until permission to do so, has been obtained from the Engineer’s Representative. Subject to such permission being obtained, trenches shall be backfilled without delay to at least the minimum extent required by the specification in readiness for pressure testing. All backfilling shall be without damage to pipes and fittings.

3.3.11 Pipe Jointing Generally

Pipe jointing surfaces and components shall be kept clean and free from extraneous matter until the joints have been made or assembled. Care shall be taken to ensure that there is no ingress of grout or other extraneous material into the joint annulus after the joint has been made.

Proprietary joints and couplings shall be used only after the Engineer’s approval and in accordance with the manufacturer’s instructions. The Contractor shall be responsible for obtaining copies of the manufacturer’s instructions as he requires. The Contractor shall be responsible for obtaining all the special tools, lubricants and appliances necessary for making the joints.

3.3.12 Flanged Joints

Flanged joints shall be made with the gaskets, nuts, washers and bolts provided. Flanges shall be properly aligned before any bolts are tightened. Two washers shall be used per bolt, one under the bolt head and the other under the nut. The tightening of the bolts shall be carried out in the sequence and to the torque recommended by the manufacturer. A torque wrench should always be used and in no case shall excessive tightening be exerted on any nut or bolt.

Jointing compounds shall not be used when making flanged joints, except that, to facilitate the making of vertical joints, gaskets may be secured temporarily to one flange face by a minimum quantity of clear rubber solution. Both threads shall be treated with graphite paste and the nuts tightened evenly in diametrically opposite pairs.

As a general rule, burying of flanged joints shall be avoided. In cases where it is approved by the Engineer, the following shall apply:
All buried flange joints shall be protected externally by painting with an approved bitumen paint and then the joint shall be wrapped using “Denso” paste, mastic, tape and outer wrap, or similar approved materials all in accordance with the manufacturer’s instructions.

Flanged adaptors and mechanical couplings, which have a RILSAN nylon coating applied by the manufacturer, require no further external protection. Where the coating of flanged adaptors and couplings applied by the manufacturer has been damaged in transport, handling or laying, such damage shall be made good in accordance with the manufacturer’s instructions before wrapping as above.

The Contractor shall supply all tools and materials necessary for compliance with this clause.

### 3.3.13 Welded Joints in Steel Pipes

The ends of pipes shall be cut or prepared as appropriate, and be free from fins, planar defects, tears and other surface defects, prior to welding. Cleaning to base metal shall extend for at least 25 mm from the end of pipe on both internal and external faces. The alignment of abutting pipe ends shall be such as to minimise the internal offset between surfaces.

Completion of internal and external protection of steel pipes shall be provided where pipes have a bituminous, epoxy or any other type of proprietary protective coating in which a gap has been left for the joint to be made. The joint and any damage to the protective coating shall be made good.

The Contractor shall submit details of the proposed welding and welding repair procedures, before production welding begins, and test welds using these procedures shall be made by the Contractor under simulated site conditions. Welders shall only make welds for which they are qualified and approved.

Joints shall be tested using non-destructive techniques, unless it is necessary to use destructive testing to achieve adequate interpretation.

### 3.3.14 Pipes Built Into Structures

Where pipelines are laid up to a structure and pass through the structure wall, two points of flexibility shall be introduced by means of flexible pipe joints or flexible couplings. One of these points shall be 500 mm from the outer face of the structure and the other located further out by another 1000 mm.

Pipes passing through the walls of water – retaining structures shall, where possible, be built into the structure in-situ, without the use of box-outs, unless otherwise approved by the Engineer.
3.3.15 Cutting of Pipes

Pipes shall be cut in accordance with the manufacturer’s recommendations and by a method which provides a clean square profile, without splitting or fracturing the pipe wall and which causes minimal damage to any protective coating. Where necessary, the cut ends of pipes shall be formed to the tapers and chamfers suitable for the type of joint to be used, and any protective coatings shall be made good, and the ends sealed.

Before any cutting of steel pipes any external sheathing shall be removed for 150 mm each side of the cut.

After the cutting of a pipe, the internal and external lining and coating must be repaired to their original condition in accordance with the manufacturers’ instructions.

The Contractor shall be solely responsible for the provision of all equipment necessary for cutting and preparing pipes.

Ovality shall be checked, and corrected if necessary by methods to the Engineer’s approval.

All materials used to repair cut ends shall be totally compatible with the original pipe materials and coatings.

All equipment tools and materials for repairing cut ends necessary to construct the works shall be supplied by the Contractor at his own expense.

3.3.16 Concrete Encasement of Pipes

Where pipelines cross roads or pass under streams and rivers or where directed by the Engineer’s Representative, the section of pipeline under the road, stream or river and for minimum distance of 0.50 m clear on either side of the bank or edge thereof or such greater distance as the Engineer’s Representative may require, shall be encased with concrete C12/15 or as shown on the Drawings, so as to provide a protective encasement to the pipe.

3.3.17 Diversion Steel Pipe Installation

The diversion works are proposed at the left bank of the river and include the inlet, the actual diversion pipe and the outlet. Their purpose is to divert river flows downstream of the dam site, so that the construction can be executed in dry conditions. Following the completion of the works, the diversion pipe will serve as an intake and bottom outlet pipe.

The total length of the diversion works is 160.0 m, with inlet elevation at +1,632.50 m and outlet elevation at +1,629.30 m, corresponding to a longitudinal slope of S=0.02. The proposed diameter is D=1.6m of a steel pipe and wall thickness 8.2 mm.
The first construction stage is to reach the foundation level of +1,634.6m and form the slope of S=0.02, as shown in Drawings. Then the excavations of the entrance walls and the pipe trench will be completed. The excavations of the outlet will be the last of the respective works, so that material can be transported outside of the upstream pits throughout the excavation phase. A 10cm blinding concrete layer will be cast and leveled after the completion of excavations and before the installation of the steel pipe.

The side retaining walls of the inlet are the first concrete structures to be constructed. The total width of the inlet varies from 2.60 m (Sta 0-4.00) to 1.60 m (Sta 0+0.00). A rectangular concrete conduit 1.60x1.60 m is constructed at Sta 0+0.00, adjusted to a circular pipe of 1.60 m diameter at Sta 0+3,00, where the upstream end of the steel pipe is placed. A 2.80x2.80 m opening, with 0.7 m width, is constructed at this location, to allow for plugging the diversion pipe with concrete before the reservoir impoundment. This operation (second concreting stage) must take place during the dry period, to be able to control the river low flows (e.g. via a small secondary cofferdam) while the concrete plug gradually acquires its full strength.

A stainless steel water stop will be provided to seal the joint between the first and second stage of concreting. The waterstop will be protected with a steel cover throughout the diversion operation, and will be cleaned of any sediments or debris prior to plugging. Moreover, a 10cm wide steel ring will be anchored in the perimeter of the pipe. A circular steel plate of 1.70 m diameter and 3.0 mm thickness will be welded on this ring to serve as formwork during the second concreting stage.

In order to weld the different pipe sections excavation expansions are foreseen, taking into account 12 m pipes. In case the pipe length is different, e.g. 6m, the pipes will either have to be welded outside of the excavation pit or the welding expansions will have to be modified on site by the Contractor, following the instructions of the Supervising Engineer.

After the placement of the steel pipe the welding seams will have to be checked, and the diversion will have to be inspected under 4atm pressure, according to the DIN 1626 Standard and the instructions of the Supervising Engineer. The first 12m of the pipe, which are upstream of the cofferdam and connected with the d=0.6m vertical intakes, are permanently below water level and do not have to be checked against pressure. Thus, this pipe section will be completed last, after the completion of audits and concreting in the downstream part.

The welds of the pipe are proposed around and inside its cross-section, and will be executed by experienced welders, qualified for these type of works. The seams will have to be checked, after a minimum of 24hours of their completion, by experienced (level 2) auditors. The respective certificates will be issued under the responsibility of the Contractor’s Quality Management Office. The tests to be performed are the following:

- 100% visual inspection according to EN970
- 100% Ultrasonic testing according to EN1714 level B
3. Structural Specification

- 10% radiographic test in selected welds, indicated by the Supervising Engineer after the delivery of the respective ultrasonic test protocols. In case of unacceptable seams that require repair additional tests will be carried out according to the EN12062 Standard.

All the above tests will conform to the quality requirements of AWWA C-206. Non-acceptable welds will be repaired and re-checked, following the standardized testing procedure. The minimum repair length is 50 mm.

Steel plugs with flanges will be placed at the upstream and downstream ends of the pipe in order to undertake the hydrostatic pressure tests. The Contractor is responsible to supply the plugs, the water to fill the diversion pipe and the necessary personnel and machinery. The hydrostatic pressure will be implemented on the pipe for 24 hours.

Following the completion of all audits reinforcement will be placed and concreting of the pipe will start. As can be seen in Drawings, concrete terraces are formed in the welding positions upstream of the dam core, to prevent water flowing downstream through the joint between the concrete surfaces and the waterproofing of zones 1 and 4 of the embankment.

Finally, after the completion of the concreting works the upstream plug is removed and the remaining 12m of the pipe can be installed, welded, tested in the location of the seams and concreted, so that the entire diversion pipe is completed. The construction of this upstream part is directly related to the construction of the intakes, which are described in subsequent paragraphs. The final step for the completion and operation of the diversion works is the installation of the rip-rap protection at the outlet invert and the placement of gabions at the outlet banks.
4. Mechanical Specification

4.1 Turbine, General

4.1.1 Reference

4.1.1.1 Standards

Except otherwise specified, the standards under which the equipment is to be designed, constructed, manufactured and tested shall be following:

- International Electrotechnical Commission (IEC)
- Association Francaise de Normalisation (AFNOR)
- Deutsche Industrie Normen (DIN)
- Verband Deutche Elektriker (VDE)
- British Standards (BS)
- National Electrical Manufacturers Association (NEMA)
- American Society for Testing and Materials (ASTM)
- American Welding Society (AWS)
- American Society of Mechanical Engineers (ASME)
- American National Standards Institute (ANSI)

It shall be understood that the latest revision or edition in effect at the time of the construction.

If it is desired to use equivalent standards or to deviate from the above-cited standards, a corresponding application together with one copy of the respective standards shall be submitted to the Owner for approval.

Machine work tolerances and allowances for the limiting sizes of mating parts for any class of metal fit shall be in accordance with ISO “system for limits and fit” or with the American Standards for “Tolerances, Allowances, and Gages for Metal Fits”.

4.1.2 Definition

4.1.2.1 Scope of Work

The work to be performed under this specification consists of designing, manufacturing, furnishing, installing, testing, putting into successful operation and guaranteeing the following electro-mechanical equipment of MUVUMBA Hydroelectric Power Plant having 2 x 500 kVA
capacities at 0.9 power factor as specified in the relevant specifications.

- Hydraulic turbines, inlet valves and auxiliary equipment
- Generators and auxiliary equipment
- Transformers and electrical equipment

The Contractor shall supply an installation comprising all material and equipment to ensure its satisfactory operation and its suitability for its intended purpose. All material and equipment together with proper design required for a modern power plant, complete in all respects that will function properly shall be provided regardless of unintentional omissions in this document. The material and equipment including all machinery, tools, accessories and spare parts shall be of the first quality, free of all manufacturing defects, imperfections and shall be in accordance with the requirements of the Contract Documents. The supply shall also include all the accessories required for the erection, dismantling, inspection, and maintenance of the equipment such as tools, ladders, slings, lifting beams, gangways, etc., also any accessories and instrumentation required for the supervision and tests, with the exceptions specified in the specifications. Initial filling of oil and grease shall be included in the supply.

All works, material and services though not expressly called for in this specification, but necessary for the complete and proper operation of the supplied equipment will be included in the present Contract.

The structural design and construction of the powerhouse building will be performed by the Civil Work Contractor.

The Contractor shall provide foundation guide drawings for all equipment in his supply together with lay-outs, loads, forces and other information necessary for the design of the foundations and other requirements of the power plant so as to enable the Civil Works Contractor to prepare the detail construction drawings and to build the power plant.

Foundation and building work drawings prepared by the civil engineers will be submitted to the Contractor in advance of construction. The Contractor shall check the suitability of these drawings for the equipment in his supply and approve or comment on them to the Owner as necessary.

The Contractor shall supply all necessary bedplates, sole plates, foundation bolts, nuts, plates, frames, trench covers, girders, steel packing, templates etc. related to his supply.

The Contractor shall level, align and securely fix the equipment in his supply on its foundation prior to concreting or grouting and shall provide all equipment necessary for levelling and alignment.

The Contractor’s supervisors shall check the concreting or grouting by the Civil Works Contractor related to the equipment in his supply (whether or not located by templates) and
shall ensure that the levels and alignment are not disturbed thereby.

The following works and equipment are out of the scope of supply and will be provided by the Civil Works Contractor:

- Steel Penstocks
- Draft Valve
- Power Plant Drainage System
- Heating, Ventilation and Air Conditioning System
- Domestic Water Supply and Sewage System
- Lighting System
- Grounding system

### 4.1.3 Requirement

#### 4.1.3.1 Packing

All equipment shall be carefully packed so as to withstand the long time transport by sea and land. The electrical equipment shall be completely protected against moisture.

The finished surface of the equipment and the portion embedded in concrete shall be protected by rust preventive means.

The spare parts shall be packed and crated firmly enough to withstand storage for a long time, and those in need of rust preventive treatment shall be so treated.

The spare parts shall be packed separately from other articles. Packages of spare parts shall carry notation, which clearly indicates that the contents are spare parts and shall be accompanied by a list of contents, which sets for the directions for storing.

### 4.1.4 Specification

#### 4.1.4.1 Turbines and Auxiliaries

- **Turbines**
  - Type: Horizontal shaft Francis
  - Number: Two (2) sets
  - Net head: 23.69 m
Output at normal head : 760 kW (at full gate)

Revolving speed : 500 rpm

Design discharge : 1.965m³/s(for one unit)

- **Inlet Valves**
  - Type : Butterfly
  - Number : Two (2) sets
  - Nominal Diameter : Appr. 700 mm.
  - Operation : Hydraulic opening and counterweight closing

- **Speed Governor**
  - Type: Electro-hydraulic

### 4.1.4.2 Generators

- **Type** : 3-phase A.C. synchronous generator, horizontal shaft, with air/watercooler.
- **Number** : Two (2) sets
- **Operating duty** : Continuous
- **Capacity** : 500 kVA
- **Voltage** : 3300 V
- **Power factor** : 0.9
- **Frequency** : 50 Hz
- **Revolving speed** : 500 rpm
- **Excitation system** : Brushless (both)

### 4.1.5. Design Condition

#### 4.1.5.1 General Information on Plant Design

**Operation**

The equipment shall be so designed as to be easy to operate, to prevent the risk of operational error, and to facilitate checking of correct operation. It shall operate in two modes,
remote control under normal circumstances, and manual control in emergency.

Since there is to be no regular surveillance in the powerhouse or switchyard, the equipment shall include all necessary sensors and equipment for the detection of faults and transmission and fault signals.

Each item of equipment shall be identified by a plate which shall indicate its main characteristics.

All bolts, shafts, nuts, and screws on rotating parts shall be correctly tightened and locked in position with the appropriate tools and parts or products.

All major gates, cocks and valves shall be fitted with position indicators showing clearly whether the system is open or closed at that point.

**Maintenance**

The equipment shall be designed so as to facilitate assembly, disassembly, maintenance and repair.

Assembly and disassembly of any one unit shall not require the disassembly of another unit not directly concerned in the operations or require special operators or tools not supplied by the Contractor, except where the nature of the equipment justifies derogation.

Replaceable or easily repairable wearing parts shall be included in wearing equipment items to render maintenance fast and economical.

Construction of different equipment items shall be standardized as much as possible in order to reduce the number of spare parts required in stock and to facilitate maintenance and replacement. Identical parts shall be manufactured to the same standards so as to be perfectly inter-changeable, and minor parts such as electric motors, valves, pumps, remote switches, relays, fuses, etc., shall be inter-changeable wherever possible.

Equipment requiring handling shall be so fitted (with lifting rings, grouping collars, etc.) as to facilitate such operations and shall be supplied with the necessary equipment (slings, lifting beams, rails etc.). Extraction tools shall be supplied with parts which may need to be separated.

**Safety**

Equipment shall be designed to ensure the full safety of staff and equipment. Suitable walkways and work areas shall be provided where required.

**Lubrication**

Special care shall be taken to ensure efficient lubrication of moving parts, and self-lubricating system shall be used wherever possible. Where manual intervention is required, the lubrication units (pumps, filters, etc.) shall be grouped in a single or reduced number of
easily accessible locations. Lubrication points shall be easily accessible and gauges shall be easily readable. The lubrication system and low pressure auxiliary equipment shall be pressure tested prior to initial operation at 1.5 times the maximum operational pressure.

The type of different lubricants shall be limited to minimum and lubricants available in Turkey shall be used as far as possible. The Owner shall be informed of their type as soon as possible so that he may choose the brand. The Contractor shall supply lubricants required up until the industrial operation of the units.

**Quality**

- **Electromechanical Equipment**
  
  All parts shall be of perfect fit and quality. The Contractor shall ensure that parts to be embedded in concrete by Civil Works Contractor are of good fit and to the dimensions shown on the drawings.

- **Electronic Equipment**
  
  Electronic equipment shall be rigorously checked and tested during and after manufacture with high precision equipment. Major parts shall be tested individually and samples of other parts shall be tested regularly.

  The equipment shall be designed to prevent ingress of all vermin and accidental contact with live parts and to minimize the ingress of dust and dirt. Materials and equipment shall resist the attack of all insects. The ambient conditions on the site have to be taken into consideration for the equipment which will be normally located in heated or ventilated ambient since during unpacking and erection, air-conditioning will not be available.

  The electronic equipment shall be equipped with suitable filters in order to eliminate any disturbance coming from Network.

**4.1.5.2 Design and workmanship**

All work shall be performed in accordance with the most advanced practice in engineering for each class of equipment and completed in a thorough workmanlike manner following the best modern practice in the manufacture of high grade equipment. All work shall be performed by mechanics skilled in their various trades.

Machining of renewable parts shall be accurate and to specific dimensions so that replacements made to drawing size may be readily installed. Like parts and spare parts shall be interchangeable.

It is not the intent to specify details of design and construction except where necessary to establish neither performance requirements, nor it is intended to set forth those performance
requirements which are adequately specified by applicable standards of design and workmanship.

The International Metric System of measurement shall be used for all work under the Contract and all units of measurement shall be expressed in that system.

**4.1.6 Structure and Materials**

**4.1.6.1 Materials**

All materials used in the manufacture of the equipment supplied shall be selected as the best available for the purpose for which it is used, considering strength, resilience, durability and other physical properties, as well as best engineering practice. They shall be new and of first class commercial quality, and free from defects and imperfections.

All materials, supplies and articles not manufactured by the Contractor shall be the products of recognized reputable manufacturers.

The material contemplated for incorporation in the equipment together with performance characteristics and other significant information pertaining to the materials shall be furnished to the Owner for approval. Materials installed or used without such approval shall be at the risk of subsequent rejection.

Material tests shall be conducted at the manufacturer’s premises or at other places agreeable to the Owner, in accordance with the requirements of the ASTM-Standards or other agreed standards. The results of these tests shall be in such a form as to provide a means of determining compliance with the applicable specifications for the material tested.

Where the Contractor desires to use stock material not manufactured specifically for the works, satisfactory evidence that such material conforms to the requirements stated in the Contract shall be furnished to the Owner, in which case tests on these materials may be waived.

The Contractor shall be responsible for the standardization of all small mechanical and electrical equipment, materials and device for the works. He shall arrange and perform the necessary coordination work with his subcontractors for the purpose of such standardization, such equipment, devices, fittings, etc. shall comprise but not necessarily be restricted to the following:

- Valves
- Gauges
- Electrical instruments and meters
- Terminals and terminal blocks
- Primary, secondary and auxiliary relaying devices
- Contactors, fuses, miniature breakers and the like
- Control devices and control switches
- Lamps, bulbs, sockets, plugs, etc.
- Lubricants

4.1.6.2 Welding

**Operation for Welding**

Members and sections to be joined by welding shall be cut accurately to size, with their edges sheared, flame-cut or machined to suit the required type of welding and to allow full penetration.

The surfaces of members or sections to be welded shall be free from rust, grease and other foreign matters for a distance of at least 50 mm back from the edge of weld.

**Welding Procedure**

All welding shall be performed by the electric-arc method, by a process at least equal to that required by the latest edition of the “standard qualification procedure” of the American Welding Society, or the corresponding DIN Standards.

**Qualification of Welders**

The Contractor shall be responsible for the quality of the work performed by his welding organization. All welders and welding operators assigned to the work shall have passed a performance qualification test for welding operators at least equal to that specified in the latest edition of the “Standards Qualification Procedure” of the American Welding Society (or DIN 8560 and 8563). All expenses in connection with making the qualification tests for welding operators shall be borne by the Contractor. Operators’ welding certificates shall be furnished to the Owner, if requested by him.

**Welding Equipment**

All welding equipment, such as welding machines, transformers, cables, electrodes, etc. for welding at the Site shall be of reputable make and suitable for the purpose intended for, Consumable material (electrodes etc.) shall be included in the price. Other materials and tools shall remain the property of the Contractor.
4. Mechanical Specification

4.1.6.3 Bolts, Studs, Nuts and Screws

They shall have standard threads and be of high quality steel.

All bolts, studs, nuts and screws (including their washers) shall be well protected against corrosion according to the site of their installation. Nuts and bolts heads shall be hexagonal in shape and truly faced.

Nuts, bolts and screws which might become loose during operation shall be locked in fastened position by means approved by the Owner.

4.1.6.4 Pipes, Flanges and Joints

All piping, flanges and joints shall be designed for the highest pressure occurring in the respective system in service, including water-hammer where appropriate.

All piping under internal pressure exceeding 16 kg/cm2, whether water or oil, shall be seamless. Piping of 50mm in side diameter and over shall be of steel unless otherwise specified.

All bends, tees and other fittings for steel piping shall be of steel.

All coupling and joining together of pipes, fittings and valves of 50 mm inside diameter and over shall, if not otherwise specified, by means of flanged joints. All flanges shall be cutter-bossed or faced at their back so that bolt-heads, washers and nuts will be down appropriately, Site welding of flanges shall be subject to the approval of the Owner.

Piping under 50 mm inside diameter may be joined together with threaded socket-fittings or approved vise-couplings.

All pipes shall be of uniform thickness, and the dimensions and drilling of the flanges shall, wherever applicable, be in accordance with the USA Standard B 16.5.

All flanged joints shall be made with jointing material being perfectly suitable for the size of flanges and operating conditions.

The jointing material shall be so proportioned that when the joint is tightened-up no part of the jointing ring protrudes into the pipe bore.

All pipes, before the joints are bolted together, shall be placed on or hung from their respective supports and lined-up so that the joints are in parallel. In making joints no springing of pipes into position shall be allowed, except where specifically approved for the purpose of relieving strains due to expansion.

All oil pipes shall be thoroughly cleaned and fitted with temporary blank flanges or plugs before being packed and dispatched.
All brackets, stays, frames, hangers and supports for carrying and steadying the pipes, including their fastenings, shall be included in the supply and completed by the Contractor at the Site. Pipes and fittings shall be supported at or near a flange wherever possible.

The supports and hangers shall be designed and arranged so that any pipe can be withdrawn without disturbing the others.

Large size piping crossing ceilings and supporting walls shall be provided with welded-on anchor collars for embedding in the concrete.

All piping carrying water shall be protected externally against sweating (condensation) by means of an approved anti-condensation wrapping or sheeting.

4.1.6.5 Valves

All valves over 50 mm bore for pressure exceeding 16 kg/cm² shall be off or gedor cast steel. Valves for such pressures but of 50mm bore or less may be of bronze.

Valves for water over 50 mm bore shall be of the external rising spindle type. Valves for oil shall be of the non-rising spindle type.

All valves shall have screw able wearing parts of corrosion-resistant materials. Their seals and sheats shall be of ample proportions and of suitable materials to ensure that galling or overloading will not occur in any service condition including partial opening.

Isolating valves shall be suitable for opening and closing against full unbalanced pressure, including closure against free discharge. If necessary, by-passes are to be provided to meet these requirements.

All valves shall be provided with hand-wheels of ample size and, where necessary, extended spindles and/or gearing so that any valve may be easily and conveniently operated by one man under any service condition.

All valves shall close with a clockwise rotation of the hand-wheel which shall be marked to show the direction of closing.

Large size valves shall be provided with means for pad locking in any position.

All brackets, stays, frames, supports and hangers necessary for carrying and steadying valves shall be included in the supply and completed at the Site.

4.1.6.6 Electrical Equipment

A. Induction motors shall be of the direct line starting-drip-proof type, and when operated, shall not develop trouble under the voltage fluctuation of ± 10%. Neither shall it show any
trouble at the rise of voltage and frequency of power source, of 30% and 35% respectively, resulting from the full load rejection of the turbine-generator.

B. Magnetic contactors used in various switches shall be made of arc resistant metal and have a sufficient capacity against rush current, and the contact part shall be free from over-wearing and misconduct for a long period of service.

C. Electrical contacts of dial type thermometers, thermal relays, oil level relays, etc. shall be able to safely break the current determined with the condition of control circuit connected to these contacts at any considerable power source condition.

D. Conductors shall not be joined by soldering except for inevitable positions.

E. Cubicles and control boards shall be provided with a fluorescent light inside (220 V AC, 20 W, 60 Hz) for interior lighting, and shall be provided with door switch. The cubicle and control box for the auxiliary equipment shall be provided with a moisture preventing heater (220 V AC, 60 Hz) with a switch and thermostat.

F. The bushings and insulators used in the equipment shall have sufficient mechanical and electrical strength.

G. Miscellaneous electrical work including wiring, conduit connections, plugs, etc. shall conform to the safety codes of IEC. All electrical wiring inside an element of the supply shall be furnished. All control and small section wiring and conduit for each component shall be brought to junction boxes or cabinet.

Wiring shall terminate in molded type terminal blocks with terminal marking strips.

Terminal blocks shall be easily accessible and suitably placed in the near surrounding of the supply.

Conduit shall be galvanized, rigid steel with threaded ends.

Fittings shall be galvanized with threaded hubs and shall have gasketed cover for tightness. Flexible conduit may be used where necessary for vibration or flexibility purposes, they should be tight with appropriate fittings.

H. Three (3) phase AC wiring shall be color coded according to the used standards. They shall be uniformed throughout the powerstation.

I. The ground terminal of the equipment shall be of the bolt-fastened type, suitable for minimum 50 mm2(equipment in the powerhouse) and 70mm2(equipment in the switch yard and high voltage equipment in the powerhouse) hard drawn copper stranded conductor or equivalent.

J. Low voltage power cable shall be stranded copper conductor, thermoplastic insulation with thermoplastic jacket overall, max. ambient temperature 40 0C.
Low voltage control cable shall have dielectric strength: 2000 V, copper conductors, thermoplastic insulation, with thermoplastic jacket overall max. ambient temperature 30°C (if necessary flame proof and/or screened).

The control cables shall have minimum cross section of 1.5 mm².

4.1.7 Painting and Mark

4.1.7.1 Corrosion Protection and Painting

General

The supply shall include the surface treatment, priming, corrosion protection and painting of the equipment furnished. Such work shall comprise the workshop- and at the Site- coating up to and including the finish painting. Unless otherwise specified the coating and painting shall be carried out in accordance with the latest edition of DIN 55928 (Protective Coatings for Steel Structures, Direction) ASTM Standards A 153, A 386, A 123 and A 120 or another equivalent approved standard.

All priming and painting material shall satisfactorily fulfill the requirements imposed by the Site conditions, as well as the stresses, to which the respective equipment is subjected during its operation. At the request of the Owner, painting samples for the different coats and colours shall be provided.

All furnished surfaces shall present a neat, pleasing appearance.

Each coat of primer and painting shall be compatible with the previous and subsequent coats. All pigmented primers and paints which will be used for priming and painting at the Site shall be delivered in sealed containers packet by the manufacturer.

The Contractor shall supply full details regarding the extent to which sand-blasting, priming and painting will be carried out in his workshop (or his sub-contractor’s, as the case may be), at the Site and after erection. A properly equipped paint-shop shall be set up at the Site using a specialist organization, experienced and skilled in the preparation and application of protective coatings at the conditions prevailing at the Site.

Materials shall be thoroughly mixed at the time of application.

It is essential that before any primer and coat of paint is applied, the surfaces are properly prepared. Such preparation shall include any cleaning, smoothing, drying and similar operation that may be required to ensure that the primer and/or paint is applied on suitable surfaces. Clean cloths and clean fluids shall be used to avoid having film or greasy residue on the surfaces being cleaned.

Each coat shall be free from runs, drops, pinholes, waves, laps, sages and unnecessary brush marks, and shall be allowed to dry or to harden before the following coat is applied.
4. Mechanical Specification

Machinery-paint may be thinned, if necessary, to permit satisfactorily application but the amount of thinner shall be kept to a minimum.

For removing rust and mill scale from structural steel, plate, sheet, piping and other steel surfaces, as well as from other parts suitable for blast-cleaning, sand-blasting shall amount to approximately 50 microns.

Parts which cannot be blast-cleaned shall be cleaned free from rust and scale by power-tool cleaning to the highest possible degree, according to the above standards or equivalent approved standards.

Blast-cleaned surfaces shall receive a quick-drying shop-coating immediately after blast-cleaning. Hand -or power-tool-cleaned parts shall be treated likewise immediately after cleaning.

All structural steel and pipes carrying water shall if provided for galvanizing-be heavily galvanized by the hot-dip process. Galvanizing shall be carried out in accordance with the ASTM Standards A 153, A 123 or VDE-Standard 0 210 and original blast-furnace raw zinc only shall be applied (ASTM B.6). The thickness of the galvanizing coating shall be approx. 70 microns.

External Surfaces

All unfinished external surfaces of the equipment and related accessories shall be thoroughly sand-blasted until a clean metal surface has been obtained and then immediately after coated with at least 3 layers of priming paint of rod lead on chlorinated rubber/synthetic resin basis (minimum thickness of the three layers 0.09 mm.)

Final coating shall be with 2 finishing coats of paint on chlorinated rubber/synthetic resin basis. The minimum thickness of the 5 layers shall be 0.15 mm.

Embedded Surfaces

The portion of equipment to be embedded in concrete shall not be painted.

Surfaces in Contact with Water

Surfaces of water passages, including the turbine runner, wicket gates, stay vanes and exposed parts, not of nonferrous, stainless steel or special non-corrosive material, shall be thoroughly sand-blasted and carefully cleaned from rust, film, scale and/or other impurities until a clean metal surface has been obtained. Porous areas, flaws, inclusions of sand, etc. shall be chipped or ground until sound metal has been reached. Repair and reconditioning of such areas shall then be carried out by electric welding with electrodes corresponding to the base material. All surfaces shall then be coated immediately with 3 layers of priming paint of red lead on chlorinated rubber/synthetic resin basis (minimum thickness of the 3 layers 0.09 mm).
Prior to the application of 2 finishing coats on chlorinated rubber/synthetic resin basis, careful elimination of remainders of oil and grease from all surfaces by means of a diluent agent of turpentine substitute, and retouching of possibly damaged areas is required.

The minimum thickness of the 5 layers shall be 0.15 mm.

Parts and Finished Surfaces to be Left Bright in Service

Same shall be protected against corrosion with on heavy coat of readily removable anti-corrosive varnish.

Surfaces Wetted by Oil

Same shall be treated and painted as stipulated for surfaces in contact with water, except that for the 2 final coats, oil-resistant varnish shall be used.

Pipe Work

- Water carrying pipes
  
  Pipes, valves and fittings, except for parts to be embedded in concrete, shall be shop-coated with priming paint.
  
  Two (2) finishing coats shall be applied at the Site, the paint needed for two (2) finishing coats shall be furnished together with the equipment.

- Oil Carrying Pipes

  Carefull cleaning of the external surfaces and pickling of the internal surfaces shall be carried out. External surfaces to be primed with 2 layers of red lead paint on chlorinated rubber/synthetic resin basis, followed by 2 finishing coats on the same basis. The minimum thickness of the layers shall be 0.12 mm.

Control Boards, Panel Boards, Cubicles, Cabinets, etc.

Carefull cleaning, if possible sand-blasting, 2 coats of oil-resistant paint shall be applied. Interior surfaces shall have at least one priming and one finishing coat of anti-corrosion paint. Exterior surfaces shall be adequately treated to be substantially corrosion-resistant with one prime coat, one filer coat and two finishing coats. Control cabinet shall be coated with non-glossy paint.

Chains, Ropes, etc.

These shall be fully galvanized.

Linings, Cover Plates, Supports, Handrails, etc.

Similar treatment and painting as specified above for “surfaces in contact with water” and
“Embedded surfaces”.

Main Transformers Painting

Synthetic resin paint shall be used for the finish paint of the exposed portion of all the equipment.

All interior surfaces of the tanks and piping shall be given at least one coat of oil-resisting paint or shall be rinsed with transformer oil immediately after sand blasting. The radiators shall be hot-dip galvanized on the outside. Internally they will be coated with an oil-resistant varnish.

The primary coat shall have a rust preventive characteristic.

Checks

The work of anti-corrosion protection will be checked by the Owner.

The check work will include:

- Check of the cleanliness of the cleaned surfaces.
- Check of the thickness and adhesion of zinc and paint coatings.
- Check of quality of the materials applied.

The thickness of the zinc and paint coatings shall be checked at about 10 check points per square meter. For the acceptance, the guaranteed thickness of the coating shall be decisive and not the number of coats applied.

Execution of the Work

In principle the painting work shall be executed in the Contractor’s shops except for the finishing coats. The priming coats and the first finishing coat respectively shall always be applied by means of a painting brush in order to obtain better adhesion.

Paintwork damaged during shipment, storage and/or erection shall be properly restored by the Contractor after thorough removal of the damaged coating. The repair coating and painting shall be carried out as per the above Specifications and reach the minimum dry film thickness stipulated.

When executing the paint work the air humidity shall not exceed 60% at the working place, and all necessary fans, air heaters, ventilation cuts and dust absorbers shall be provided by the Contractor.

The Contractor shall furnish a suitable quantity of each priming and finishing paint for touch-up work at the Site, after the end of the guarantee period.
Repair of Defects

The Contractor shall carefully repair all defects occurring to the surface protection during the guarantee period (cleaning of defective parts by sand-blasting if necessary, re-application of the different protective coatings).

Special care shall be given to transition zones where new and original coatings come together. Should the defect be one for which the Contractor is liable, all related repair cost shall be borne by the Contractor. The Contractor shall obtain Owner’s approval with regard to the colors before executing coating and painting works.

Shades and Colours

The shades of the finishing coats, as well as the colour code to which they shall be correspond will be settled after the contract award.

4.1.7.2 Name Plates

All major equipment shall be provided with a securely fastened nameplate showing the maker’s name, model, serial number, year of manufacture, main characteristics data of the respective equipment and further relevant information specified in the applicable standards or necessary for the proper identification of the equipment involved.

The Contractor shall supply and install also all label plates and other labelling (of the screw-on type) on control boards, control desks, panels and other places where required for operational, functional and safety reasons.

The labelling, size of the plates and their location shall be subject to approval by the Owner. A sample label-plate (with indication of the material used) with lettering shall be submitted for this purpose. The number of sizes of the plates shall be minimum.

The plates shall be in English.

4.2. Francis Type Turbine

4.2.1 Scope of Work

The Work to be done under this specification consists of designing, manufacturing, furnishing, delivering, installing, testing, putting into successful operation and guaranteeing the following related equipment for MUVUMBA Hydroelectric Power Plants which are situated in a common building, complete with their appurtenances and spare parts, all in accordance with the Contract Documents:

- Two (2) 380 kW horizontal shaft Francis type
The Contractor shall supply an installation comprising all the equipment required to ensure its satisfactory operation and suitability for its intended purpose. All material and equipment required for a complete installation that will junction properly shall be provided regardless of unintentional omissions in from this specification.

The Contractor shall provide in his supply all electrical equipment and cables required to connect the electrical installation of the equipment specified in the following sections.

The supply shall also include all accessories required for the erection, dismantling and inspection and maintenance of the equipment such as tools, ladders, sealings, lifting beams, gangways etc. and also any accessories and instrumentation required for the tests.

4.2.2 Requirement

Description

The turbine shall have a guaranteed full gate outputs of not less than 1000 kW for turbine shaft under design net heads of 23.69 m for MUVUMBA HPP.

Efficiencies

The efficiencies of the turbine for MUVUMBA HPP at 50, 60, 70, 80, 90 and 100% of full gate output under design net heads shall be guaranteed and stated in the bid.

The Contractor shall supply performance curves showing efficiencies, output and discharge of the turbine covering from 50% to 100% of full rated power output for each type of turbine at the design net heads.

Turbines Weighted Average Efficiency

The turbines shall be designed so that the weighted average efficiency obtained by the following formula will have maximum value.

\[ Y = 0.15 \times Y_{100} + 0.1 \times Y_{90} + 0.1 \times Y_{80} + 0.1 \times Y_{70} + 0.15 \times Y_{60} + 0.4 \times Y_{50} \]

where \( Y_{100}, Y_{90}, Y_{80}, Y_{70}, Y_{60} \) and \( Y_{50} \) are the turbine efficiencies at the turbine output of 100%, 90%, 80%, 70%, 60% and 50% under normal (design) net head 23.69 m for units.

The Bidder shall also specify and guarantee the calculated weighted average efficiencies in his bid. This data will be taken into account for comparison of the tenders.

Speed

- Nominal Speed

The nominal speed of the unit shall be 500 rpm for units.
Runaway Speed

The maximum runaway speed that the turbines is guaranteed not to exceed under maximum net head with no-load or excitation on the generator, shall be stated with guaranteed characteristics.

All parts of the turbines including flywheel shall be designed and constructed to withstand safely the stresses caused by operation at maximum runaway speed, and under these conditions the stresses shall not exceed two thirds of the yield strength of the materials.

Critical Speed

The critical speed of the rotating parts shall be at least 30% higher than the maximum runaway speed.

Speed Rise

The maximum speed rise shall not exceed 50% of rated speed in the most unfavourable condition (full load trip under maximum head). The Contractor shall indicate the speed rise foreseen for sudden tripping at 100% (guaranteed), 75%, 50%, and 25% (for information) of the full gate output at maximum head for 23.69

Pressure Rise

The maximum pressure rise in the spiral casing in the most unfavourable conditions of head and sudden change of discharge shall not exceed 40% of maximum static head for units.

Flywheel Effect

Estimated natural flywheel effect of turbines and generators rotating parts is about 2.32 t.m² for units. Minimum total GD2 of the units required to obtain the above value of speed rises shall be determined by the contractor. In case additional flywheel is necessary, it shall be supplied.

Wicket Gate Closing Time

The exact value of closing time shall be determined and fixed by the Contractor and calculation sheets justifying the values of the pressure rise, speed rise and GD2 shall be submitted with the proposal.

Guide Bearing Temperature

The metal temperature of the turbines radial and thrust bearings shall not be higher than 65°C under any operating condition when cooling water temperature is 25°C.

Excessive Pitting Caused by Cavitation

The Contractor shall guarantee the durability of runners against excessive cavitation of
4. Mechanical Specification

4.2.3 Specification

4.2.3.1 Number Required
Two (2) sets.

4.2.3.2 Type and Description
The turbines shall be of horizontal shaft Francis type with a welded steel plate spiral case and a steel inclined conical type draft tube and other appurtenances as hereafter specified.

The rotation of the turbines shall be clockwise when viewed from generator side.

The turbines shall be suitable for direct connection to 50 Hz alternating-current generators having a nominal rating of 500 kVA at 0.9 power factor.

A thrust and radial bearing which is called combined bearing will carry all weights of rotating parts (runner + shaft + flywheel) as well as hydraulic thrust of the turbine runner. Provisions shall made in turbine design to minimize the unbalanced hydraulic thrust under all operating conditions.

Each turbines will be served by a penstock branch having 700 mm inside diameter furnished by the Contractor. Emergency and maintenance closure of each turbine will be by a butterfly type inlet valve as specified in Specification Inlet valve.

4.2.4 Hydraulic and Operation Conditions

The turbine will operate under the following conditions of heads and discharge.

Intake Water Elevations (above sea level)
- Water level in regulator : 1402.84 (app.)

Tailwater elevations (above sea level)
- 2 Units in operation (Q = 3.93 m3/s) : 1377.57 m (asl)

Net Head
- MUVUMBA HPP : 23.69 m
Turbine Elevation

Centerline of the spiral case shall be at elevation for:

- MUVUMBA HPP : 1402.84 m (asl)

Discharge

The total equipped discharge for two (2) units.

- MUVUMBA HPP : 3.93 m³/s

4.2.5 Structure and Materials

4.2.5.1 General

The different parts of the turbine shall be arranged so that they can be easily removed for inspection, cleaning or repair.

All parts shall be adequately sized so as to work at a normal ageing rate for the loadings of all hypothetical operating conditions. Especially for limit conditions (runaway), the working stresses of various parts shall not exceed (2/3) two-thirds of the yield strength of the material used.

The Contractor shall bind himself to supply a complete assembly in perfect operating conditions and equipped with all necessary safety devices.

This description is made for one turbine but is valid for two (2) units, of both ratings.

4.2.5.2 Runner

The runner shall be of the Francis type and shall be constructed and delivered in one piece.

It shall be made of integral nickel-chrome stainless steel casting construction and shall be designed and manufactured to safely withstand runaway condition stresses.

The runner shall be coupled on the turbine shaft by keys.

To facilitate future replacement of the runner, the connection part shall be designed for easy replacement. The connection bolts shall be secured against loosening.

A runner cone attached to the hub of the runner shall be provided to guide water when it leaves the runner.

Ample vent holes through the runner hub or other means shall be provided to reduce the pressure acting on the turbine head cover and the thrust load acting on the runner.
4. Mechanical Specification

All runner surfaces exposed to the flow shall be chipped and ground to accurate template forms resulting in perfectly even surfaces without holes, depressions, projections or other defects liable to cause cavitation or premature wear.

Removal of the runner shall be made from downstream side.

The finished runner shall be balanced statically and dynamically at the manufacturer's shop before dispatch. In the event of damage in transportation it shall be balanced again at the site at the Contractor's expense.

The runner shall meet the cavitation requirements specified in specification Guarantees and Penalties.

4.2.5.3 Turbine Shaft

The turbine shaft shall be of forged carbon steel properly heat treated. Forged flange at the generator side forming an integral part of the shaft shall be provided to couple the shaft to the generator shaft or flywheel. The bolts required for the flange connection shall be provided.

The design of the shaft shall be such that its critical speed shall be above 30% of the runaway speed of the turbine. This critical speed of the combined turbine and generator shafts shall be carried out in agreement with the generator manufacturer.

The turbine shaft dimensions shall be such as to ensure that it neither vibrates nor distorts at any speed, including runaway. The diameter of the turbine shaft shall be matched to that of the generator shaft.

The shaft shall be free from visible defects or imperfections. It shall be suitably machined over its full length and polished where the guide bearing to be fitted and at all points accessible for purposes of checking shaft alignment. The shaft shall be subjected to ultrasonic test to confirm that it has no fault.

The turbine and generator manufacturers shall cooperate and jointly provide all the arrangements necessary to ensure the correct coupling-up and assembly of turbine and generator shafts. They shall also agree on all dimensions associated with this shaft connection.

The alignment of the combined turbine and generator shafts shall be checked by means of a rotational check at Site.

The Contractor shall supply all the instruments required for this alignment check. Permissible tolerances on the turbine and generator shaft alignment shall be as quoted in NEMA Standards Publications.
4.2.5.4 Turbine Thrust and Radial Bearing

The combined bearing shall be of slide type and designed for horizontal shaft turbines.

It shall be located on the shaft so that access to the shaft seal would be possible without dismantling the bearing.

Housing and Shell

The housing of the bearing shall be of cast steel or cast iron and have a rigid design in order to carry all radial and thrust loads safely.

The bearing shells shall be spherically seated type and consist of a steel body which is lined with a lead based white metal and shall be designed against heavy engineering application such as continuous operation condition, long life, etc. The metallic bond between steel and white metal shall be examined by ultrasonic test.

Radial Bearing

Radial bearing shall be plain cylindrical type and shall be equipped with a hydrostatic jacking device to avoid wear and high friction torques at creeping speeds and when starting up and slowing down of the unit.

Thrust Bearing

The axial loads on the shaft should be taken up by the thrust pads with appropriate number which are fitted on the bearing shoulders.

Interchangeability of the pads shall be possible

Bearing Seals

The bearing shall be equipped at both ends with adequate type of seals to prevent the bearing from external effects.

Lubrication

Lubrication and cooling of the combined bearing shall be effected by means of loose or fixed lubrication rings. Additionally, an external oil supply system for each turbine-generator unit shall be also provided. This external oil supply unit shall be designed so that it will be able to feed the sufficient amount of lubrication oil needed for the bearings of turbine and generator and as well as pressurized oil to the hydrostatic jacking device during starting and stopping of the unit.

External oil supply unit shall comprise the followings :

- One oil container
- One AC motor driven oil pump
4. Mechanical Specification

- One DC motor driven oil pump (Emergency Pump)
- High pressure motor driven oil pumps for hydrostatic jacking device
- Control valve for oil supply
- Pressure gauge with contact switch
- Non-return valves
- Pressure limiting valves
- Double filter with by-pass valve
- Water-oil heat exchanger
- Thermostatic control valve for cooling water
- Shut-off valves
- Oil temperature control
- Oil level control
- Tank heater
- Drain facilities of the container
- Other necessary instruments.

Cooling

A cooler with finned or smooth tubes in the oil sump shall be provided to cool the oil with a water temperature of 25°C. The cooling water shall be supplied from the cooling water system of the plant.

Operation Requirements of the Bearing

The combined bearing shall operate under the conditions listed below without damage, without bearing metal temperature rise above 65°C.

- Continuous running at any speed between 90% and 110% of normal speed.
- at least 15 minutes or for the time required for the unit to come to a complete standstill (wicket gate closed) from maximum speed occurring during operation after a full-load rejection, whichever is longer, without cooling water.
- at least 30 minutes operation at runaway speed.
Instrumentation

Additional to the instruments supplied with external oil supply unit described above, each bearing shall be provided with necessary measuring control and safety equipment such as sensors, thermostats, thermometers, level gauges.

The instruments listed in OPERATION CONTROL SYSTEMS FOR THE TURBINES in connection with operation and control of the units shall be provided for each bearing.

4.2.5.5 Turbine Shaft Seal

The shaft seal shall be durable and very efficient in preventing leakage of water. It shall be designed and constructed so that inspection, adjustment and replacement can be easily made. The agreement shall make the best possible provision for access to the gland without dismantling other equipment on the turbine cover.

The shaft seal housing shall be sufficiently rigid to prevent distortion. All bolts, nuts and screws shall be stainless steel. Filtered water shall be taken from the unit cooling water system to lubricate and cool the gland surfaces, if required. Fine filters shall be provided for each unit. Necessary pipes for drain of the water leaked from the seal shall be provided.

A thermometer shall be provided for measuring gland temperature, fitted with two contacts for initiating on alarm at just above normal max. temperature and shutdown at higher temperature.

4.2.5.6 Turbine Spiral Case, Stay Ring and Stay Vanes

The spiral case, with stay rings and stay vanes, shall be made as an integral assembly unit having proper hydraulic form and shape.

Spiral Case

The spiral case shall be of welded construction and formed of steel plates.

After completion of welding interior stresses shall be relieved and 100% of radiographic inspection shall be performed to confirm that there are no void, slags, inadequate melting, cracks, under- cuts, etc.

Preparation for welding and weld inspections shall be carried out as described in GENERAL TECHNICAL SPECIFICATIONS.

Tools and equipment for the inspections shall be prepared by the Contractor.

Stay Ring and Stay Vanes

The stay ring shall comprise two rings connected rigidly together by the stay vanes.
4. Mechanical Specification

The stay ring and stay vanes shall be of steel plate for welding structure and stay vanes may be of cast steel welded to the rings at shop.

An appropriate number of stay vanes shall be designed to guide the flow of the water properly to the wicket gates and to carry the tensile load due to the water pressure in the spiral case.

Stay ring and stay vanes shall be welded to the spiral case at the Contractor's shop and shall be delivered to the site as one piece.

The weld between spiral casing and stay ring shall be subject to 100% radiographic examination.

Inlet Extension

The spiral case shall be provided with an inlet pipe whose upstream side will be welded to the downstream pipe of inlet valve at the site.

Pipe Connections

The under-mentioned seats for pipe connections and taps shall be provided for each spiral case and the exact location of these connections shall be indicated on the drawings.

- Spiral case drain connection
- Two stainless steel taps equally space around the inlet section of the spiral case for net head measurements and for connections to pressure gauge on the turbine control board shall be furnished.

The necessary piping between taps and gauges shall also be supplied by the Contractor.

Jacks and Fixtures

The spiral case shall be provided with a suitable number of lugs for the application of jacks and the fitting of anchor bolts. The necessary jacks and anchor bolts required for horizontal and vertical setting of the spiral case during erection and for supporting and maintaining in position during concreting shall be supplied.

Air Admission and Vent Valve

The Contractor shall furnish, if necessary, an automatic air admission and vent valve mounting on the crest of the spiral case. It shall be opened automatically to permit escape of air while filling the spiral case with water.

4.2.5.7 Head Cover, Bottom Ring, Discharge Ring and Wearing Ring

The head cover, bottom ring and discharge ring shall be made of cast steel or welded plate
steel.

The head cover shall be flanged for bolting to the stay ring and sealing box. The head cover shall be dimensioned and reinforced so as to withstand, without excessive deformation, the maximum water pressure and all other forces acting upon it.

The underside of the head cover shall be designed so as to minimize friction and eddy losses in the space between the runner and the head cover.

Water passing through the labyrinth shall be suitably drained in order to prevent excessive pressure under the head cover or excessive hydraulic thrust on the runner hub.

On the head cover, appropriately sized inspection holes shall be provided at four locations with uniform spacing so that the runner side clearances can be measured without dismantling the head cover. These holes shall be covered with lids or plugs.

The bottom ring shall be secured to the discharge ring by welding or it may be cast integrally with the bottom ring.

The wearing rings shall be provided, one on the head cover and the other on bottom ring opposite the runner periphery. They shall be removable and exchangeable, and made of corrosion-resisting steel of a different hardness from that of the runner, so as to prevent seizing in case of rubbing.

The inner surfaces of the head cover and bottom ring where facing guide vanes shall be equipped by stainless steel face plates or filled by stainless steel welding.

The face plate and wearing ring shall be solidly secured to the head cover by stainless steel setscrews.

4.2.5.8 Wicket Gate (Guide Vanes)

The turbine shall be provided with an appropriate number of wicket gates. The wicket gates shall be made of either cast or fabricated stainless steel in one piece with their stems.

The number of wicket gates, stay vanes and runner buckets shall be coordinated in a manner to insure that the turbine will operate without vibration.

The wicket gates shall be uniform in shape and their cross-sections shall be such as to direct properly and accelerate gradually the water entering the runner with a minimum of friction and hydraulic disturbance.

Each wicket gate shall be accurately formed and finished, and shall be interchangeable with all others. Furthermore, its material shall be of a different hardness from that used for the opposite face plates.

The gates shall be suspended in the proper position between bottom ring and head cover,
and means of adjustment for this shall be provided. Stops shall be provided to limit the travel of a wicket gate disconnected from the control linkage, of adequate strength to resist the maximum impact forces that could occur.

In the event of loss of governor oil pressure, the wicket gates shall drift toward the closed position.

### 4.2.5.9 Wicket Gate Stem Bearing and Seals

The bearing shall be self lubricating teflon-bushed bearings.

The lower bearing shall be located on the bottom ring and the upper bearing shall be located on the head cover.

An adjustable seal shall be fitted on the upper part of the wicket gate stem to prevent leakage. The material used in this seal shall be of fully reliable quality. A pressure seal consisting of rings of synthetic rubber (or similar), shall be provided for each wicket gate stem.

### 4.2.5.10 Operating Ring and Linkage

An operating ring shall actuate the turbine wicket gates through a gate linkage and, in turn, shall be actuated by forged steel rod connected to servomotor, mounted on the generator side.

The operating ring shall be cast steel or welded steel component, all welds being heat-treated in the latter case. It shall have self-lubrication guide at points of contact with the stationary parts.

The linkage to each gate shall be separately adjustable. Each linkage shall have a conveniently replaceable protective device designed to break when its gate is prevented from moving. Breakage of this protective device shall not cause failure of adjacent devices.

The linkage shall be designed and made to withstand the highest loads likely to affect it in the most severe operating case.

The entire linkage system shall be conveniently accessible for inspection, adjustment and repairs.

All hinge pins shall be self-lubricating. The linkage shall be carefully designed and manufactured to ensure minimum lost motion and wear. Facilities for individual wicket gate adjustment shall be provided to ensure perfect contact between any two adjacent gates when fully closed, also the simultaneous even opening of all the gates.

Suitable stops shall be provided to restrict angular wicket gate travel in the event of a safety
link failure, and thus to prevent the disconnected gate from interfering with the operation of the remaining wicket gates and runner.

4.2.5.11 Gate Servomoter

The turbine shall be provided with one double acting oil servomotor to control the operating ring, and hence the opening and closing of the wicket gates.

Pressure oil shall be supplied to the servomotor by the governor pressure system and controlled by the governor system. All pipes between the servomotor and governors shall be supplied by the Contractor.

The cross-sectional area of the servomotor shall be such that, under the minimum oil pressure available from the governor, they can produce the maximum force required to operate the wicket gates under the worst possible load and discharge conditions, from the fully open to the fully closed position, within the time specified to ensure that acceptable overpressure and over-speed limits are not exceeded.

Suitable conveniently operated mechanically locking systems shall also be provided on the servomotor, to firmly maintain the wicket gates in the fully-open or fully-closed positions even with full oil pressure in the servomotor cylinders.

A remote transmitter for wicket gate opening shall be provided.

A position indicator shall be fitted to the servomotor or to the operating ring to give an accurate indication of the wicket gate opening.

The opening rate shall be slightly reduced towards the end of stroke. The rate of closure shall also be reduced between the speed no-load and fully closed wicket gate positions by means of an adjustable device which does not in turn affect the opening rate.

Attention shall be paid on the location, construction and foundation base to ensure against any movement or any other damage to the servomotor due to this forceful action.

All the necessary mounting screws, bolts, studs, anchor rods and base-plates required to secure the servomotor to the concrete, in such a way as to prevent slip or angular displacement during operation and to withstand maximum thrust load in either direction, shall be supplied.

The servomotor shall be tested at the shop under a pressure equal to 1,5 times the normal operating maximum pressure with a type of oil similar to that which will be used in the governing oil system.
4.2.5.12 Draft Tube

The draft tube shall be made of welded steel plates using rolled steel for general structure.

The Contractor shall be responsible for the hydraulic design of the complete draft tube profile and shall furnish the draft tube up to the tailrace.

The draft tube shall be so designed to permit dismantling of the runner from draft tube side.

It shall consist of a conical entrance portion, an elbow and a discharge portion. Connection of the elbow to the entrance and discharge portions shall be done by means of flanges. The part immediately downstream of the runner shall have stainless steel surface not less than 3 mm thick extending 200-300 mm from the runner skirt.

The discharge portion shall be embedded in the concrete and opened to the tailrace channel. Its outside surfaces shall be provided with sufficient ribs for reinforcement to surrounding concrete.

Adequate anchor rod attachments shall be provided by the Contractor for securely maintaining the alignment and anchoring tube in concrete. The draft tube shall be equipped with internal bracings as necessary to prevent distortions during transportation and embedding.

For measuring the vacuum pressure inside the draft tube a compound gauge shall be provided.

4.2.5.13 Flywheel

If necessary, a flywheel shall be installed on the turbine shaft between the turbine and generator.

The flywheel shall be made of integral steel casting construction and designed and manufactured to safely withstand runaway condition stresses.

The flywheel could be also used as the brake ring when the breakers are put into operation.

The flywheel shall be covered with an approved guard fabricated from welded plate and structural steel.

4.2.5.14 Unit Breaking System

A braking system shall be provided for each turbine whereby the period of slow running of the machine before stand-still will be minimized.

The brake system shall be designed as to operate automatically and continuously by oil pressure when the speed of the unit decreases about 20% of the rated speed and to bring
the unit to stand-still within a reasonable time without injurious heating.

Brakes shall be automatically reset after complete stop of the unit. Braking operation shall be also performed manually from the unit local control board.

The brake shoes shall be of replaceable type. A stopper shall be provided to prevent the brake shoe holder advancing excessively in case the brake shoe shall have been abraded. The position switches with contacts to prevent unit from starting unless all brakes are in “off” position shall be provided.

The pressure oil for the braking system shall be supplied from the governor oil system.

4.2.5.15 Instruments and control Equipment

The turbine shall be provided with instruments, controls and alarm and protection switches and devices for complete operation and regulation in order to obtain the highest degree of safety and reliability in operation and continuity of service.

Instruments, control and protection devices shall be located so as to be easily accessible, clear and readable.

All transmitter, contacts etc. for remote operation and remote indication of the turbine shall be provided.

Thermometers and Temperature Detectors

Temperature detectors for the guide bearing shall be of resistance type with platinium element giving 100 ohms at 0°C complying with the applicable standards. (Pt 100).

The indicators to be installed on the turbine local control board shall be similar to those which will be provided in the main control room. All transmitters and wiring between temperature detectors and indicators shall be provided by the Contractor.

Necessary thermal relays for alarm and emergency shutdown of the unit shall be also provided.

The type and characteristics of the temperature detectors, indicators, transmitters and relays shall remain subject to the Owner’s approval.

Oil Level Gauges and Oil Level Relays

Oil level gauges shall be fitted with appropriate protective cover for preventing damages. Normal, upper and lower limit oil levels shall be inscribed on the gauges. The type of the level gauges shall be subject to the Owner's approval.

Oil level relays shall be accurate and reliable in operation. They shall be installed in convenient positions to enable easy inspection and checking of operation, and shall be
provided with two sets of normally open contacts for alarm (one for low, the other for high), and one contact for emergency shut down of the unit.

The relays shall be automatically reset as soon as the oil level returns to the designated value.

**Water Flow Relays**

A water flow relay shall be provided on each discharge line from the various cooling systems of electro-mechanical equipment. The relay shall transmit an alarm to the control board in the control room in the event that cooling water stops to flow, and shall be provided with an alarm contact. The water flow relay with sight shall be of simple construction and shall be accurate and reliable in operation.

**Motor Operated Shut of Valve**

Motor operated valves shall be provided in the cooling water piping. Gate type shut-off valve shall include motor, reduction gearing, limit switches and integrally mounted reversing starters, all housed in one water-tight assembly. The motor shall be suitable for 380 V, 3. phase 60 Hz. continuous duty and of sufficient size. The valve shall also be provided with a handwheel for manual operation.

A mechanical indicator shall be provided on the valve to indicate the open and close position of the valve. The operator shall be provided with limit switches for governing the travel in the closing and opening direction. Additional contacts for remote indication and interlock shall be provided.

**4.2.5.16 Miscellaneous Metal Works**

**Walkways, Platforms, Ladders, Covers**

Working, operating and inspection walkways and platforms complete with non-slip type floor plates or gratings, stairs, ladders, and hand railings shall be furnished where necessary to provide convenient access to all operating equipment.

**Foundation Requirements**

All equipment to be provided shall be furnished with all necessary anchor bolts, nuts, washers, sole plates, structural steel supports, anchor tie rods and turnbuckles, and other material necessary for anchoring of the equipment to the foundation.

**Piping and Appurtenances**

The Contractor shall supply all water, oil and air pipes, valves, pipe supports, studs, bolts, washers, rings, packings and such other appurtenances required to make the turbine a complete unit in all respect ready for satisfactory operation.
Corrosion-Resisting Screws, Bolts, Nuts, etc.

Any screws and nuts used to assemble the various turbine components subject to frequent adjustment or dismantling during operation shall be of stainless steel or bronze.

4.2.5.17 Accessories

Three (3) sets of turbines, the following accessories shall be supplied.

Name Plate Three (3) sets

Particulars to be described on the name plate shall be as follows: type of turbine, output, effective head, discharge, rotational speed, runaway speed, name of manufacturer, production number and date. Dimensions and fitting place will be indicated in the drawings for approval.

Wire ropes for installation One (1) lot

Oil

The oil for the oil pressure system and for the turbine bearing shall be furnished by the Contractor. The lubrication oil for the guide bearing and hydraulic oil for the oil pressure system if possible shall be of the same quality. The brand and grade of the oil will be decided after award of the Contract.

4.2.6 Special Tools

Wrenches, tools, etc One (1) set

With the turbines there shall be furnished one (1) complete set of standard and special wrenches for dismantling the turbine, together with special tools and lifting devices required for handling.

4.2.7 Spare Parts

The Contractor shall furnish the following spare parts for each individual power rating.

All spares furnished shall be interchangeable with the corresponding original parts. They shall also be the same material and workmanship, and shall have all the features and provisions of the corresponding original parts.

Wicket gate elements with bushings

Three (3)
4. Mechanical Specification

Breaking links or Shear pins for wicket gates of one turbine
One (1) Set

Lever and key for one wicket gate
Three (3) Sets

Thrust pads and bearing shell for thrust and radial bearing
One (1) Set

Complete set of packing and seals for one turbine
One (1) Set

Wearing rings and facing plates
Three (3) Sets

Limit switches
One (1) of each type

Pressure gauges
One (1) of each type

Oil level gauges
One (1) of each type

Relays
One (1) of each type

4.3. Speed Governor

4.3.1 Scope of Work

The Work to be done under this specification consists of designing, manufacturing, furnishing, delivering, installing, testing, putting into successful operation and guaranteeing the following related equipment for MUVUMBA Hydroelectric Power Plants which are situated in a common building, complete with their appurtenances and spare parts, all in accordance with the Contract Documents:

- Two(2) electronic type speed governors

The Contractor shall supply an installation comprising all the equipment required to ensure
its satisfactory operation and suitability for its intended purpose. All material and equipment required for a complete installation that will junction properly shall be provided regardless of unintentional omissions in from this specification.

The Contractor shall provide in his supply all electrical equipment and cables required to connect the electrical installation of the equipment specified in the following sections.

The supply shall also include all accessories required for the erection, dismantling and inspection and maintenance of the equipment such as tools, ladders, sealings, lifting beams, gangways etc. and also any accessories and instrumentation required for the tests.

4.3.2 Structure and Materials

Number Required

Two (2) Sets

Scope

This section specifies the detailed requirements for the design, manufacture and testing of the speed governors for the Francis type turbines described in Specification Francis type Turbine.

Each governor shall be complete and independent and shall include:

- An electronic governing head protected against surge and high frequency interference from the electrical supply line or from various electrical inputs and outputs,
- The various components of the hydraulic power system such as pilot valves, safety electrovalves, distributing valves, etc. for controlling the turbine and inlet valve,
- The electrical feedback system,
- Speed signal and power supply systems,
- Piping, wiring and all other accessories and all the components required to constitute a completed assembly for regulating the speed.

Complete specifications and preliminary drawings shall be submitted with the bid.

Requirements

- Type and Description

  The governor head shall be of electronic type, either with speed signal and power supply by a pilot alternator (PMG) or with speed signal supplied by a speed
The governor shall be furnished with necessary auxiliary devices for manual and remote control of the turbine and inlet valve. Said auxiliary devices shall permit transfer from one method of control to the other without disturbing the operation of the turbine and inlet valve.

The governor shall allow for an easy switching over from automatic control to hand control and vice-versa, at any load.

All transmitters, contacts, etc. for remote operation and remote indication of the necessary governing value shall be included in the supply.

The signalling and control equipment of the governing shall be mounted on the local control board of the unit.

The IEC publication 308 "International Code for testing of speed governing systems for hydraulic turbines" is a correlative document of the present specification.

- Performance

General

The governor furnished under this specification shall sense the speed of turbine rotation, determine an error signal and therefrom develop a hydraulic control signal of sufficient power to regulate the main servomotor to control the hydraulic turbine in accordance with the operating requirements.

Capacity

The governor shall have adequate capacity and shall be of sufficient size to supply necessary quantity of oil to the servomotors to operate the wicket gates from closed to full open or vice-versa under the maximum head including water hammer and with minimum operating pressure in the governor oil tank.

Wicket Gate Operating Times

The wicket gate operating times from the fully-closed to fully-open position or vice-versa shall be stated by the Contractor, so that the speed rise and pressure rise will under no case exceed the values specified in paragraphs 2.4.5 and 2.4.6. of the Specification Francis type Turbine.

It shall be possible to modify the rate of movement of the main servomotors such that the opening and closing time shall be adjustable.

This adjustment shall positively restrict the flow of oil so that the operation of any control, safety, or auxiliary device cannot cause the main servomotors to move at
a rate which exceeds the maximum for which the adjustment has been set. A secure and rigid means shall be provided to prevent unauthorized changing of the opening or closing times after commissioning.

Stability

The governor shall provide stable turbine speed control at the rated speed when not under load, or when running at the rated speed at any isolated load condition up to and including maximum turbine load. The governor shall also be capable of controlling with stability the turbine output throughout the full range up to maximum load with the generator connected to the network.

Speed and output fluctuations shall be indicated by the Bidder.

Dead Time

The elapsed time from the initial speed change of the turbine to the first movement of the servomotor for a sudden load change shall be less than 0.2 seconds.

Dead Band

With the turbine running at its rated speed, the total amplitude of speed variations not resulting in any measurable difference in the gate servomotor position shall not exceed 0.1% of the rated speed at any gate opening. Measurement shall follow IEC rules.

Speed Droop

The speed droop shall be capable of adjustment to values between 0 and 10% with the turbine running.

Range of Speed Changer Adjustment

The speed changer shall be enable the wicket gates to be opened fully with the turbine running at 105% of its rated speed and maximum speed drop regulation. It shall be possible by the same means to run the turbine when not producing energy at speeds of 90% of its rated speed with zero speed droop regulation.

The speed changer shall be capable of being operated by remote control from the control room.

Gate Opening Limits

The gate shall be provided with opening limits. The gate opening limits shall be effective for all modes of governor operation. It shall be possible to remotely control the gate opening limits.
4. Mechanical Specification

- **Auxiliary Functions**

  **Speed Switches**

  Auxiliary speed switches shall be supplied, mechanical or electrical, independently adjustable. All switches shall have electrically separate contacts and be readily changeable from circuit opening to circuit closing, as desired. The switches shall be supplied as follows:

  1) One (1) switch to provoke tripping at overspeed to initiate shutdown.

  2) One (1) switch to initiate operation of synchronizing equipment.

  3) One (1) switch for excitation of the generator.

  4) One (1) switch to close at 20 percent speed and below to be used in a brake circuit at unit shut-down.

  5) One (1) switch to initiate hydrostatic jacking device of the turbine bearing in start-up operation.

  6) Space shall be provided for two additional switches.

  **Gate Position Auxiliary Switches**

  These switches are operated by gate position mechanism. Each switch shall be adjustable to close or open its contacts at any point over the full gate movement, as desired.

  **Automatic Gate Lock Control**

  A selenoid operated hydraulic gate lock control assembly complete with manual control and all required piping shall be provided. The selenoid shall be suitable for continuous duty. The device shall be arranged that the gate lock may be controlled manually.

  The gate lock mechanism shall be provided with limit switches.

  **Overspeed Safety Devices**

  The Contractor shall furnish in particular two automatic overspeed safety devices, one electrical, the other entirely hydro-mechanical, which shall both control the complete closing of the turbine wicket gates when the speed exceeds a predetermined value.

  **Creep Detector**

  Each unit shall be equipped with a creep detector which shall detect and indicate creep of the unit and shall have alarm contacts.
• Speed Signal Generator, Power Supply System

The supply shall include:

Either an independent self excited, permanent magnet type AC generator (PMG unit) designed for direct connection to the main generator exciter shaft furnishing power and speed signal to the governor head.

Or a speed or frequency detector of the proximity sensor type or equivalent, eventually combined with the speed switches. In this case the Contractor shall also supply the necessary power supply unit to adapt the internal service possibilities to the needs of the governor.

In case of using a PMG generator, the Contractor shall keep close coordination with the Generator Manufacturer and shall furnish all necessary data and drawings to the Generator Manufacturer to accomplish complete coupling and installation.

• Governor Cubicle

The electrical section of the governor shall be mounted in a cabinet vermin-proof and dust-proof design with anti-condensation heaters.

The Adjustment of the governor characteristics shall be possible during operation.

Access to the back of the panel shall be provided, and the design of electrical circuits and major components shall be such as to facilitate easy removal of any faulty section and the plugging-in of a replacement.

A chart shall be provided for speedy location of a faulty section or component, and full details of all sections shall be provided so that repairs can be effected by checking and replacing components.

The governor cubicle shall be installed at the same level, rather close from the unit local control board described in Electrical specification.

4.3.3 Acceptance Tests

The value range and function of each item specified shall be tested in accordance with International Electrotechnical Commission Publication 308 "International Code for Testing of Speed Governing Systems for Hydraulic Turbines".
4.3.4 **Spare Parts**

The Contractor shall furnish the following spare parts for each individual power rating.

All spares furnished shall be interchangeable with the corresponding original parts. They shall also be the same material and workmanship, and shall have all the features and provisions of the corresponding original parts.

- **Printed cards for electronic governing head**
  One (1) complete set

- **Speed signal generator or speed detector**
  One (1) complete set

- **Potentiometers**
  One (1) of each type

- **Main and auxiliary distribution valves**
  One (1) of each type

- **Switches**
  One (1) set

- **Packings and seals**
  One (1) set

- **Lamps**
  One (1) set

- **Fuses**
  Ten (10) of each type

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4.4. **Inlet Valves**

4.4.1 **Scope of Work**

The Work to be done under this specification consists of designing, manufacturing, furnishing, delivering, installing, testing, putting into successful operation and guaranteeing the following related equipment for MUVUMBA Hydroelectric Power Plants which are situated in a common building, complete with their appurtenances and spare parts, all in accordance with the Contract Documents:
Two (2) butterfly type turbine inlet valves

The Contractor shall supply an installation comprising all the equipment required to ensure its satisfactory operation and suitability for its intended purpose. All material and equipment required for a complete installation that will junction properly shall be provided regardless of unintentional omissions in from this specification.

The Contractor shall provide in his supply all electrical equipment and cables required to connect the electrical installation of the equipment specified in the following sections.

The supply shall also include all accessories required for the erection, dismantling and inspection and maintenance of the equipment such as tools, ladders, sealings, lifting beams, gangways etc. and also any accessories and instrumentation required for the tests.

4.4.2 Specification

4.4.2.1 Number Required

Two (2) Sets

4.4.2.2 Type and Description

The inlet valves shall be of pressure oil operated "butterfly" type with horizontal shaft construction and counter weight closing.

The valves will be installed on the valve pits just before the turbine spiral casings in the machine hall. In order to facilitate erection of the valve a dismantling joint shall be provided on downstream end of each valve.

The inlet valve together with by-pass line and operating equipment shall be designed to fit into space available with proper regard to accessibility and passageway. The valve shall be supported on concrete pedestals and secured by anchor bolts.

The valve body, disc, and operating mechanism shall be designed for installation and removal from above by means of powerhouse travelling crane.

4.4.3 Design Condition

4.4.3.1 Design Characteristics

Flow Capacity

The valves shall have sufficient capacity to allow maximum flow of turbine discharge.
Design Strength

The valves shall be designed to withstand the maximum transient hydraulic pressure and shall be free from vibration and any abnormality under the whole operating range of turbine including any transient conditions of operation.

Diameter

The inside diameter of the valves are approximately 700 mm both for Three (3) units. The exact diameter shall be determined by the Contractor.

Full-Flow Shut-Down

The valves shall be so designed as to be capable of closing from fully opened position under the conditions of maximum flow at maximum head. Furthermore, the valves shall be capable of closing safely and completely against full unbalanced flow occurring as a result of a burst of the downstream piping within the valve chamber.

Operating Time

The opening and closing of the valve shall not exceed 45 seconds excluding the operating time of the by-pass valve and shall be adjustable.

Leakage

Amount of leakage passing through the gaps shall not exceed the amount of 3 liters per minute under the maximum static head, including leakage through the by-pass valve. The valve shall be designed for repacking without disassembly of any of major parts.

4.4.3.2 Control and Operating Mechanism

The opening of each inlet valve shall be performed by one servomotor and closing shall be by the closing weights and the disc's hydraulic self closing tendency.

The servomotor shall be operated by pressure oil supplied from the governor oil pressure system.

An oil operated by-pass valve with associated shut-off valve and piping shall be furnished with each inlet valve. The operating mechanism including that for the by-pass valve shall be provided with a manual locking device which can lock both the main and by-pass valves when they are closed. When the valve is locked, opening of the valves shall be impossible.

Operation of the valve shall be such that in opening, the by-pass valve is opened first and after balancing the pressure on both sides of the valve an electric circuit shall be closed through a differential pressure switch then the main valve will be opened. In closing, the main valve is closed first and by pass valve will be closed after the main valve is closed.
The following modes of control shall be provided for:

- Manual locally from the unit local control board,
- Manual remote from the control room,
- Automatically (for starting-up and stopping of the respective generating set).

The controls shall be so arranged that the motion of each inlet valve can be reversed at any time during opening or closing stroke.

All local control and indicating devices shall be mounted on the unit local control board of the turbine. The necessary contacts for remote control from the control room shall be also provided.

### 4.4.4 Structure and Materials

#### 4.4.4.1 Valve Disc and Trunnion

Valve disc shall be of either cast steel or welded-steel plate or combination of both with trunnions attached in accordance with the manufacturer's normal practice. The trunnions shall be of forged stainless steel material and securely fastened to the valve disc. Attention shall be given to a convenient and smooth shape of the disc so as to minimize disturbances of the water and head losses.

The axis of the disc and of its trunnions shall be horizontal. The disc shall be designed with sufficient strength not to cause any distortion or deformation nor to cause any abnormal vibration when the valve is in open position or during operation.

For sealing of the disc against the stainless steel seat on the valve body an easy replaceable sealing ring at the disc's circumference shall be used. The sealing ring shall be firmly fixed to the valve disc by metal fitting.

All surfaces of the trunnion shall be properly machined with the bearing and sealing surfaces polished.

#### 4.4.4.2 Valve Body

The valve body shall be fabricated of rolled steel plate for welded structure or made of carbon steel casting as in one piece.

Both ends of the body shall have properly faced and drilled flanges for making watertight connections with the upstream and downstream piping.

A highly erosion-resistant stainless steel sealing ring (either of weld deposited make or of screwed-in type) shall be provided at convenient place in the valve body.
4. Mechanical Specification

The trunnion bearing blocks (housings) shall be of first class cast steel and welded on the body so as to form an integral part. The bearings shall be self-lubricating type and shall be incorporated in the valve body together with readily renewable packings for the trunnions.

The body shall be provided with sufficient number of conveniently arranged lifting lugs.

Support of the valves shall be by pads welded onto the valve body. The supporting face of the pads shall be machined so to ensure perfect setting and alignment of the valves. The necessary base or sole plates, complete with anchor bolts shall be furnished.

An indicator with scale pointer shall be provided for at each valve to indicate the disc position. It shall be of reasonable size and located at a convenient height.

The supply shall include also a mechanical locking device to hold the valve in closed position against the maximum force of opening cylinder.

4.4.4.3 By-pass Valve

By-Pass valve shall be dimensioned to allow filling of the spiral case and intermediate pipe in a reasonable time and designed to assure the least amount of corrosion due to cavitation and cause the least amount of noise and vibration during operation.

The by-pass shall comprise an oil operated by-pass valve and a hand operated shut off valve.

The by-pass valves shall be made of cast steel with wear parts of corrosion resisting material.

The operation of by-pass valve shall be carried out by oil pressure commonly used for the main valve. Hand operated shut-off valve normally locked in open position shall be installed in the upstream connection to permit repair or inspection of the by-pass valve without emptying the penstock.

The by-pass piping shall be of steel with steel flanged connections, and the part between the oil operated valve and the downstream pipe shall be made of stainless steel.

The necessary bolts and gaskets for a complete installation shall be furnished.

4.4.4.4 Upstream Piping

Each inlet valve shall be provided with an upstream pipe of welded plate steel construction. It shall be conical or straight, have a length suitable for welding connection of the valve body to the respective penstock.
The downstream end shall be equipped with a flange matching properly the upstream flange of the valve body. Its upstream end shall be welded to the penstock at site. The penstock will be welded plate steel construction and provided and installed by the Civil Works Contractor. The making of the welded joint between upstream piping and the penstock will be carried out by the Contractor and end preparation for welding shall be subject to approval of the Owner.

The following take-offs, taps etc shall be provided on each upstream pipe:

One (1) take-off with one (1) shut-off valve for cooling water supply.

One (1) take-off with one (1) shut-off valve for penstock drainage.

One (1) take-off for by-pass piping

Two (2) stainless steel taps and one pressure gauge (with air exhaust valve and stop valve) for measuring penstock pressure.

Piping between pressure gauge and the tap is included in the supply.

The supply shall also include all necessary bolts, nuts, screws, attachments, packings, jointing material, etc. The material of connection elements shall be stainless steel.

4.4.4.5 Downstream Piping

Each inlet valve shall be provided with a downstream pipe of welded plate steel construction. The upstream end shall be equipped with a colour flange and loose intermediate flange so as to ensure a telescopic fitting of the valve body with downstream pipe. Its downstream end shall be for site welding to the spiral case extension pipe and have, therefore, an allowance in length approx. 200 mm.

The following take-offs, taps, openings, etc. shall be provided on each downstream pipe:

One (1) take-off with one (1) shut-off valve for spiral case drainage

One (1) take-off for the inlet valve by-pass pipe connection

The supply shall include also all necessary bolt, nuts, screws, packing, jointing material, etc. The material of Connection elements shall be stainless steel.

4.4.4.6 Operating Mechanism

Opening of each valve shall be effected through one oil pressure actuated servomotor. During closing of the valve by counterweights, this servomotor shall act as a brake. The servomotor may be attached to the valve body or rested on the valve chamber's floor. In the latter case heavy supporting plates with anchor bars, fastening, etc. shall be provided for
the respective floor area.

All parts shall be designed and constructed so as to exclude distortions and deflections under all operating conditions. Special attention shall be paid to case in inspection and maintenance.

The cylinder shall be of cast steel and the bore shall be machine ground so as to assure a concentric and smooth finish from porosities and other defects.

The pistons shall be of nodular cast iron or steel, with the piston assembly fastened properly to the piston rod. The finish shall be so as to ensure perfect fit with cylinders. Piston rings, packings and cup leathers shall be designed and arranged so that inspection and replacement can be effected without disassembly of the cylinders. The piston rods shall be either of stainless steel or of S.M. steel with nickel chromium protective layer. Dimensioning of the rods shall be so as to transmit all operational forces without deflections. All pivots shall be preferably of self-lubricating type.

The closing weights of the valve shall be of cast iron and fastened securely to the lever.

4.4.4.7 Miscellaneous Metalworks

All multigrid checkered or grated floor plates, canal covers, platforms, stairways and railings necessary for operation, servicing and maintenance of the inlet valves and their accessories shall be furnished by the Contractor.

All necessary frames, anchoring material, structural steel supports, fastenings, attachments and other necessary installations shall form part of the supply.

4.4.4.8 Test Cover(Bulkheads)

The supply shall include one test cover for two (2) inlet valves in order to carry hydrostatic pressure testing at the Contractor's shop and at the Site (if required by the Owner).

All packings and joining material for these tests shall be furnished.

4.4.4.9 Wiring

The necessary electrical wiring and electric conduits between the inlet valve and the unit local control board shall be furnished.

The required remote control and indicating devices and the wiring between control room and unit local control board will be furnished.
4.4.4.10 Lubrication
All bearings and trunnions shall be provided with low friction self lubricating bushes and shall be designed for easy replacement.

4.4.4.11 Accessories
One complete set of ordinary and special spanners, wrenches, special tools, slings, ropes, etc. for the proper erection and maintenance of the inlet valves shall be supplied.

4.4.5 Painting to the Interior Surface of the Inlet Valve
All surfaces of water passages of the inlet valves shall be shop-coated with two coat of tar-epoxy resin paint and shall not undergo painting at the site, however painting of the connecting portion to the penstock and spiral case shall be coated at the site. All painting works shall be carried according to General Technical Specification.

4.4.6 Spare Parts
The Contractor shall furnish the following spare parts for each individual power rating.

All spares furnished shall be interchangeable with the corresponding original parts. They shall also be the same material and workmanship, and shall have all the features and provisions of the corresponding original parts.

<table>
<thead>
<tr>
<th>Item</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rubber ring and other packings</td>
<td>One (1) Set</td>
</tr>
<tr>
<td>Limit switches</td>
<td>One (1) of each type</td>
</tr>
<tr>
<td>Servomotor piston rings</td>
<td>One (1) set</td>
</tr>
</tbody>
</table>

4.5. Pressure Oil Supply System

4.5.1 Definition

4.5.1.1 Scope of Work
The Work to be done under this specification consists of designing, manufacturing, furnishing, delivering, installing, testing, putting into successful operation and guaranteeing the following related equipment for MUVUMBA Hydroelectric Power Plants which are situated in a common building, complete with their appurtenances and spare parts, all in accordance with the Contract Documents:
Two (2) sets of pressure oil supply system for wicket gates and inlet valves

The Contractor shall supply an installation comprising all the equipment required to ensure its satisfactory operation and suitability for its intended purpose. All material and equipment required for a complete installation that will function properly shall be provided regardless of unintentional omissions in from this specification.

The Contractor shall provide in his supply all electrical equipment and cables required to connect the electrical installation of the equipment specified in the following sections.

The supply shall also include all accessories required for the erection, dismantling and inspection and maintenance of the equipment such as tools, ladders, sealings, lifting beams, gangways etc. and also any accessories and instrumentation required for the tests.

4.5.1.2. Use

The system shall be used to supply required pressurized oil for the governor and inlet valve.

4.5.2 Requirement

4.5.2.1 Number Required

Three (3) Sets

4.5.2.2 System

Each system shall consist of two (2) sets of oil pumps (one for regular use and the other for stand-by), one (1) oil sump tank, one or two hydraulic accumulators and other necessary equipment and accessories.

The pressure oil system shall have a capacity sufficient to assure the operating guarantees of the turbine and inlet valve.

Continuous running system by an unloader shall be applied. The start and stop of these pumps shall be controlled automatically and also manually by the switch mounted on the Unit Local Control Board.

Oil pressure variation applied to the system is, in principle, as follows.

Oil pressure variation.

Ps : Pressure of safety valve operation

Po : Maximum oil pressure of normal operating range
P1 : Minimum oil pressure of normal operating range
P2 : Oil pressure of the stand-by oil pump starting
P3 : Oil pressure of the alarm announcing
P4 : Oil pressure of the quick stop relay actuation
P5 : Allowable minimum oil pressure
  (Minimum oil pressure to shut the guide vanes)

4.5.2.3 Oil Pump

The oil pumps shall be of the vertical shaft, directly coupled electric motor driven, screw or rotary gear type.

Continuous running system by an unloader shall be applied. The delivered oil quantity of one pump set shall not be less than the oil quantity enough to close the guide vanes without supplying oil from the oil pressure tank.

The pumps shall be interconnected so that they can be operated independently. The necessary valves shall be furnished so as to permit complete isolation of any pump from the oil system and to permit removing the pump for repairs without shutting down the governor.

4.5.2.4 Induction Motors

The motors shall be direct-connected to the pumps and shall be of 3-phase AC 380 V, 60 Hz, low-starting current, induction type designed for full voltage starting. The motors shall have closed conduit boxes and windings shall have moisture and oil-resistant insulation.

4.5.2.5 Hydraulic Accumulator

The hydraulic accumulators shall be of bladder type which use the nitrogen as compressible fluid for storing the oil under pressure.

The accumulator shall be designed, constructed and tested in accordance with the approved standards.

The accumulator shall have a sufficient capacity to complete the following duties.

- The oil pressure shall be not less than the pressure P4 after the operation of two (2) strokes of guide vane servomotor starting at the pressure P1 without oil supply from the oil pump.
4. Mechanical Specification

- The oil pressure shall not be less than the pressure P5 after the operation of one stroke of guide vane servomotor at the pressure P4 without oil supply from the oil pump.

- The remained oil quantity at pressure P5 shall not be less than 10% of the total effective oil quantity.

The following accessories shall be furnished with the hydraulic accumulators;

- Pressure relays (for the conditions of turbine start, oil pump start, alarm, turbine stop and other necessary conditions.)

- Safety valve

- Oil supply and drain valves

- Inert gas supply valve

- Name plate and instruction plate

- Other necessary instruments

One hydraulic accumulator will be provided as spare for two units.

4.5.2.6 Sump Tank

Each governor shall be provided with a sump tank having a capacity of not less than 110% of the total oil quantity in the entire governor il system (oil in hydraulic accumulators, sump tank, servomotor, piping, etc), plus oil required for inlet valve hydraulic system.

The sump tank shall be provided with suitable access openings. It shall be equipped with an oil level indicator, a low level switch, an oil thermometer with oil temperature switches and shall have suitable connections for filling and draining the tank, connections for a portable oil purifier.

An oil cooler shall be provided with connecting piping and valves to limit the maximum oil temperature.

Double oil filter screens shall be provided in the sump tank, arranged so that one screen is operating whilst the other is removed for cleaning. A duplex type of filter shall be provided for oil supplied to the electro-hydraulic valve. It shall be possible to change over the filter elements without momentary reduction of output pressure and each filter element shall be suitable for convenient removal and cleaning.

The inside surfaces of the sump tank shall be free from any cracks, open joints, and blind holes liable to trap dirt in the oil. All internal welds shall be continuous. All joints shall be welded. Outside surfaces shall be perfectly smooth and free from scratches, bumps or rough
welds, to ensure the absence of undesirable reflections when painted. All traces of rust, oil, grease and dirt, shall be removed from both inside and outside surfaces. Inside surfaces shall be sand-blasted and then painted immediately with an oil-proof enamel to prevent corrosion.

4.5.2.7 Control
A local control and indicating panel shall be provided at an approved position on the pumping set, incorporating the following instrumentation.

- A pressure gauge to indicate the pressure of hydraulic accumulator
- Motor control switches to enable each motor to be switched off, operated manually or placed under automatic pressure switch control,
- A changeover switch so that either pump can be operated as main pump with the other as standby.

Another changeover switch will be provided on the Unit Local Control Board to allow motor control to be effected either from there or from the pumping sets.

4.5.2.8 Piping and Valves
The Contractor shall supply all pipes and valves between the pump units, oil sump, pressure oil tank and servomotors of inlet valve and wicket gates and also all drain piping leading to the oil sump. All pipes shall be dimensioned for a maximum oil flow velocity not in excess of 5 m/sec over the full range of servomotor travel at its fastest rate.

The piping shall be seamless steel tubing with suitable pipe fittings.

The Contractor shall as far as possible carry out the maximum amount of pipe work at the shop, subject to erection, transport and handling limitations, in order to reduce work at the site to a minimum.

The Contractor shall supply all pipe hangers and supports required to prevent vibration or displacement of the pipes due to sudden changes of pressure in the circuits.

Contractor shall also supply all studs, bolts, washers, collars, oil seals, pipe brackets, etc. required for the erection of the oil circuits.

4.5.3 Spare Parts
The Contractor shall furnish the following spare parts for each individual power rating.
4. Mechanical Specification

All spares furnished shall be interchangeable with the corresponding original parts. They shall also be the same material and workmanship, and shall have all the features and provisions of the corresponding original parts.

- Oil pump complete with motor One (1) set
- Hydraulic Accumulator One (1) set
- Unloader One (1) set
- Instruments and gauges One (1) each type
- Safety valves One (1) each type
- Packings One (1) set
- Valves One (1) of each type
- Electromagnetic contactors One (1) of each type
- Filters One (1) of each type
- Relays One (1) of each type

4.6. Compressed Air Supply System

4.6.1 Scope of Work

The Work to be done under this specification consists of designing, manufacturing, furnishing, delivering, installing, testing, putting into successful operation and guaranteeing the following related equipment for MUVUMBA Hydroelectric Power Plants which are situated in a common building, complete with their appurtenances and spare parts, all in accordance with the Contract Documents:

One (1) sets of Compressed Air Supply System for following applications

The Contractor shall supply an installation comprising all the equipment required to ensure its satisfactory operation and suitability for its intended purpose. All material and equipment required for a complete installation that will junction properly shall be provided regardless of unintentional omissions in from this specification.

The Contractor shall provide in his supply all electrical equipment and cables required to connect the electrical installation of the equipment specified in the following sections.

The supply shall also include all accessories required for the erection, dismantling and inspection and maintenance of the equipment such as tools, ladders, sealings, lifting lugs etc. and also any accessories and instrumentation required for the tests.
4.6.2 Structure and Materials

4.6.2.1 Quantity
One (1) set/two(2) units

4.6.2.2 Applications
The compressed air supply system shall be applied for the following purposes:

- The draft tube water level depression for pump starting (If necessary)
- Compressed air supply for the pressure oil tanks of the speed governor and inlet valve
- Compressed air supply for generator-motor brake

4.6.2.3 System
One (1) compressed air supply system shall be central supply system for three (3) turbine units and shall consist of two (2) air compressors with induction motors, three (3) main air tanks, three (3) brake air tanks, various valves, piping and control devices. Outline of the air system is indicated on the attached drawings.

In normal operation, all air piping of the system shall be pressurized to the rated operating pressure.

Two (2) sets of air compressors shall be provided, one (1) regular operation, the other for standby. The air compressors shall be controlled from remote control system (DCS) manually or automatically according to the air pressure in air tanks. The compressors shall start by turns with time delay to prevent excessive starting inrush currents. Local control station shall be provided to operate each compressor manually.

The compressed air used for the pressure oil tank for speed governor and inlet valve shall be supplied from governor air tank by an automatic air supply valve. The automatic air supply valve shall be controlled by an automatic oil level regulator mounted on the pressure oil tank.

The compressed air supply into the governor air tank shall be supplied automatically from the main air tanks through a pressure reducer and an automatic air valve which is controlled by the air pressure.

The compressed air used for the brake air tank shall be supplied from the governor air tank through a pressure reducer and an automatic air valve which is controlled by the air pressure.

The compressed air supply to and exhaust from the draft tube and runners shall be
controlled by the electromagnetic valves in accordance with the automatic sequential control of the pump-turbine to be provided in the remote control system.

While the water level in the draft tube and runners is depressed, the compressed air supply from the main air tank shall be controlled automatically by the water level detection device. Local control station for the manual operation of compressed air supply to and exhaust from the draft tube and runners shall also be provided.

The compressed air supply and stopping for the generator-motor braking shall be automatically controlled by the electromagnetic valve in accordance with the automatic sequential control of the generator-motor from the DCS.

4.6.2.4 Air Compressor

The air compressors shall be water cooled, directly coupled motor driven type or belt drive type.

Two(2) sets of regular use air compressors shall have sufficient capability to recharge the main air tanks within two (2) hours from the allowable minimum air pressure to the minimum normal pressure after three (3) times depressions of draft tube water level including leaked air from draft tube.

To reduce the inrush current at the compressor starting, a star-delta switch shall be furnished for each compressor.

Vibration and noise of compressor shall be as small as possible. The noise muffling facilities shall be set for the compressors.

The lubricating oil system for the compressors shall be closed circulation oil supply system.

The crank case of compressor shall be designed to hold the minimum possible condensation of water in the case.

The following accessories shall be supplied for each compressor.

- Filters One (1) lot
- Check valves One (1) lot
- Safety valves One (1) lot
- Water flow transmitters One (1) lot
- Air releasing valves One (1) lot
- Automatic valves for cooling One (1) lot
- Cooling device for the compressor One (1) set
• Disposal equipment for released air One (1) set
• Unloader valve for starting One (1) set
• Lubricating equipment One (1) set
• Drainage equipment of air and water One (1) set (with silencers and oil separation tank)
• Other necessaries One (1) lot

4.6.2.5 Induction Motor
The motor shall be of the horizontal shaft, totally enclosed fan cooled type rated for 3-phase, AC 400-230 V, 50 Hz.

4.6.2.6 Control Device
A complete instrumentation and control system to ensure safe and reliable manual and automatic operation of compressed air supply system shall be provided.

4.6.2.7 Main Air Tanks
The total capacity of main air tanks (four (4) sets) shall be determined so that they are capable of four (4) times water level depressions in a draft tube including leaked air without any air supply from the air compressor.

The first depression for each draft tube shall be achieved by two (2) main air tanks for each unit.

The main air tank group for each unit shall be normally isolated by the closed automatic valve, but the valve shall be open when another depression is required after the first depression had been completed for each unit.

The tank shall be able to withstand 1.5 times the design pressure of the tank. The design pressure of the main air tank shall be greater than the delivery air pressure of air compressor safety valve.

Oil-resistant paint shall be applied to the interior surface of the tank.

Each main air tank shall be furnished with the following accessories including seats.

• Air pressure transmitters One (1) lot
4. Mechanical Specification

(for compressed air supply and stop to the pressure oil tank for speed governor, to the braking air tank and to the main air tanks, etc)

- Automatic control valves One (1) lot
- Air supply and drain valves, check One (1) lot
  valves and necessary stop valves
- Pressure reducer One (1)
- Safety valve with alarm contacts One (1)
- Manhole One (1)
- Other necessary One (1) lot

4.6.2.8 Brake Air Tanks

Each brake air tank shall have a sufficient capacity to enable the generator to provide at least two (2) times of air brake operations and general use of the station service without any air supply from the main air tank.

The tank shall be able to withstand 1.5 times the design pressure of the tank.

The compressed air shall be supplied from this tank for the miscellaneous use of the station service, and the tank shall be provided with the pressure reducing valve and stop valve for this purpose.

Oil-resistant paint shall be applied to the interior surfaces of the tank.

Each brake air tank shall be furnished with the following accessories including seats.

- Air pressure gauge One (1)
- Air pressure transmitters One (1) lot

(for alarm, compressed air supply, generator-motor brake and other necessary conditions)

- Automatic control valves One (1) lot
- Air supply and drain valves, check One (1) lot
  valves and necessary stop valves
- Pressure reducer One (1) for each kind
- Safety valve with alarm contacts One (1)
- Manhole One (1)
4.7. Cooling Water System

4.7.1 Scope of Work

The Work to be done under this specification consists of designing, manufacturing, furnishing, delivering, installing, testing, putting into successful operation and guaranteeing the following related equipment for MUVUMBA Hydroelectric Power Plants which are situated in a common building, complete with their appurtenances and spare parts, all in accordance with the Contract Documents:

Cooling water system starting from the upstream of strainers up to check valve on the discharge line of each turbine-generator set

The Contractor shall supply an installation comprising all the equipment required to ensure its satisfactory operation and suitability for its intended purpose. All material and equipment required for a complete installation that will junction properly shall be provided regardless of unintentional omissions in from this specification.

The Contractor shall provide in his supply all electrical equipment and cables required to connect the electrical installation of the equipment specified in the following sections.

The supply shall also include all accessories required for the erection, dismantling and inspection and maintenance of the equipment such as tools, ladders, sealings, lifting beams, gangways etc. and also any accessories and instrumentation required for the tests.

4.7.2 Structure and Materials

Number Required

Two (2) Set for turbine and generator units.

Use

The System shall provide cooling water for;

- Generator air coolers
- Generator guide bearings
- Turbine trust & guide bearing
- Governor oil sump tank coolers
4. Mechanical Specification

- Turbine shaft seal

Requirements For Construction And Characteristics

- System

Four Strainers shall be supplied for four (4) units

Water for shaft seal lubrication shall be supplied from the corresponding unit Cooling Water System through a duplex fine filter.

One discharge pipe shall be provided for each unit

Cooling water shall be provided from the penstock branch at just upstream of inlet valve and strained through two automatic, self-cleaning, pressure type strainers (one as a stand-by). A motor operated remote controlled shut-off valve shall be installed on the main supply line of each generating unit. The operation of this valve shall be interlocked with the starting and stopping sequence of the unit.

- Strainers

The strainers shall be of the automatic, permanent, self-cleaning pressure strainer type. The strainer shall be of carbon steel construction, flanged, suitable constructed for the operating pressure and complete with isolating hand-controlled valves, air vent valve and drain valve, cleaning water collector with motor gear-operator, and an indicating and automatic control device.

The filter element shall be suitable to retain any solids liable to block the circuits and shall be of a type conveniently dismantled and replaced when necessary.

The automatic control device shall include:

A clogging indicating device,

Control box,

An automatic cleaning water valve.

- Motor Operated Shut-Off Valves

Motor operated valves shall be provided in the cooling water piping. Gate type shut-off valve shall include motor, reduction gearing, limit switches and integrally mounted reversing starters, all housed in one water-tight assembly. The motor shall be suitable for 380 V, 3 phase 60 Hz continuous duty and of sufficient size to open and close the valve against an unbalanced pressure with a reasonable speed and maximum torque switch setting suitable for operation at approximately 4 bars. The operator shall also be provided with a hand-wheel for manual operation.

A mechanical indicator shall be provided on the operator to indicate the open and
close positions of the valve. The operator shall be provided with limit switches for governing the travel in the closing or opening direction. Additional contacts for remote indication and interlock shall be provided.

- **Water Flow Relays**

  The water flow relays shall be provided on the secondary side of the generator air cooler, and to bearings coolers of turbine-generator units. The relay shall transmit an alarm to the control board in the control room in the event that cooling water stops to flow, and shall be provided with an alarm contact. The water flow relay with sight shall be of simple construction and shall be accurate and reliable in operation.

- **Thermometers and Temperature Detectors**

  Rod type thermometers shall be equipped at inlet and outlet of each cooling circuit of the water supply system. A resistance type temperature detector shall be equipped at inlet of the cooling water supply system. It is to be used in combination with temperature recorder furnished by the Electrical Equipment supplier. The detector shall have a resistance of 100 ohms at O°C (Pt 100).

- **Piping and Valves**

  All piping and valves as required to ensure satisfactory operation of the cooling system shall be supplied.

  Pipe supports, hangers, jointing materials and pipe insulation to prevent sweating as required for proper installation of the system shall be provided. Piping material for both exposed and embedded parts shall be black steel pipe.

  The piping, valves, etc. shall be of an approved quality and shall be suitable for the service and the pressure. The piping after installation shall be tested at a pressure 50% above the working pressure.

- **Wiring**

  The Contractor shall supply all wiring required to connect up the various items of equipment to the Unit, Local Control Board and/or Power Plant Control Room.

- **Miscellaneous**

  Drain cocks, vent valves and air vents are necessary to ensure satisfactory operation when filling or draining the system shall be provided.

### 4.7.3 *Spare Parts*

The Contractor shall furnish the following spare parts for each individual power rating.
4. Mechanical Specification

All spares furnished shall be interchangeable with the corresponding original parts. They shall also be the same material and workmanship, and shall have all the features and provisions of the corresponding original parts.

- Strainer One (1)
- Duplex fine filter One (1)
- Filter elements One (1) of each type
- Motorized valves with motor One (1) of each type
- Water flow relay One (1) of each type
- Thermometer and temperature detectors One (1) of each type

4.8. Water Drainage System

4.8.1 General

The drainage system of the powerhouse shall comprise one system, which shall be provided for Nos. 1 units. The system is provided with a sump pit for water collection and evacuation to the tailrace.

The drainage system shall convey water from the various source of leakage or discharge to the sump pit. Principal water sources considered in the design of the system are leakage from powerhouse walls and foundation drain. Water collected in the sump pit is automatically pumped to the tailrace by two (2) drainage pumps under water level switch control.

4.8.2 Structure and Materials

drainage & Sump pump

Sump Pump : Submerged Pump

Condition : Q0.1m3/s x H4.5m

Power Source : 400 v x 50Hz x 3Φ x 3.7kW

The drainage pump is of submersible type. The automatic control of the drainage pump units shall be such that either pump unit may be used for normal operation, while the other pump unit serving as a stand-by use. The stand-by unit shall be arranged to start automatically when the water level in the sump pit exceed predetermined level and stop automatically when the water level goes down.
The drainage pumps shall be controlled by two level switches of each independent and different type of the other for water level control without failure.

The water in the draft tube shall be drained to the tailrace through the sump pit, for inspection or repair of the turbine.

4.9. Oil Purifying Equipment

4.9.1 Definition

Oil purifying equipment shall be provided 2 types of purifier, the one is vacuum type for insulation oil, the other is a centrifugal type for hydraulic oil.

The clean oil will be taken to the vicinity of the turbine or generator bearing, governor sump or transformer in the shipment container and transferred to the receiving sump through a hose by gravity or a transfer pump. All oil used to fill a sump will pass through a strainer to ensure the cleanliness of the oil. The transfer cart will be mobilized manually. Dirty oil will be carried from the generating equipment to a shipment container on the transfer cart.

4.9.2 Structure and Materials

4.9.2.1 Vacuum Oil Purifier

A vacuum oil purifier shall be provided to dehydrate, de-aerate, purify and filter the transformer insulating.

If the purifier uses disposal filtering or oil dispersion material the Contractor shall supply with the unit not less than 5 years supply of such material.

The quantity of filtering material shall be sufficient to allow changing the filtering media after an annual treatment of the oil in each of transformers. The filtering media shall be changed after the treatment of the quantity of oil in each sump or system.

If water is used for producing a vacuum or compensate all water supply and drain hoses shall be supplied with suitable couplings.

The suction and the discharge oil resistant hose shall be provided, each about 30 meters in length for connection to the pump strainer and oil pumps or transformers. These hoses shall also be used for connecting the oil purifier to transformer. All hose connections shall be the swivel coupling type and corresponding adapters and coupling halves shall be provided on each transformer fill and drain connection.

An electrical oil resistant insulated cable shall be provided of 30-meter length with a metal plug suitable for the outlets.
4. Mechanical Specification

The purifier shall be movable and provided with all attachments appropriate to obtaining easy manoeuvrability. The purifier shall be rated for the 400-230 volt A.C. power and shall take power from the distribution panel.

4.9.2.2 Centrifugal Type Oil Purifier

A centrifugal type oil purifier shall be provided to dehydrate, de-aerate, purify and filter the generating unit lubricating oil.

The purifier shall have all components, controls, valves, thermostats, pump drives, motors, starters, relays, filters etc.

If the purifier uses disposal filtering or oil dispersion material the Contractor shall supply with the unit not less than 5 years supply of such material.

The quantity of filtering material shall be sufficient to allow changing the filtering media after an annual treatment of the oil in each of the bearing sumps governors and transformers. The filtering media shall be changed after the treatment of the quantity of oil in each sump or system.

If water is used for producing a vacuum or compensate all water supply and drain hoses shall be supplied with suitable couplings.

The suction and the discharge oil resistant hose shall be provided, each about 30 meters in length for connection to the pump strainer and oil pumps. These hoses shall also be used for connecting the oil purifier to the sump. All hose connections shall be the swivel coupling type and corresponding adapters and coupling halves shall be provided on each sump fill and drain connection.

An electrical oil resistant insulated cable shall be provided of 30-meter length with a metal plug suitable for the outlets.

The purifier shall be movable and provided with all attachments appropriate to obtaining easy manoeuvrability and to locating the purifier adjacent to the oil container on the generating unit. The purifier shall be rated for the 400-230 volt A.C. power and shall take power from the nearest motor control centre.

4.9.2.3 Oil Tester

A portable dielectric oil tester shall be provided. The rating shall be 1 kVA, with maximum capacity of a test voltage of 70 kV. The test voltage shall be adjustable by the voltage regulator and indicated on a kilovolt-meter. The unit shall be complete with switches, instruments and accessories.
4.9.2.4 Transfer Cart
The contractor shall supply a transfer cart of steel construction with oil resistance tired casters lifting lugs and pull bar.

4.9.3 Shop Test and Inspection
The equipment to be supplied under this section shall be tested to recent International standards & codes at Contractor's plant before shipment.

4.10. Cranes and Hoist

4.10.1 Reference

4.10.1.1 Standards to be Applied
Unless otherwise is stated, all materials, equipment and the related tests shall be in accordance with the latest versions of the following standards or their equivalents:

- Deutsche Industrie Normen (DIN)
- Verbandes Deutscher Elektrotechniker (VDE)
- American Society for Testing Materials (ASTM)
- American Welding Society (AWS)
- National Electrical Manufactures Association (NEMA)
- American Society of Mechanical Engineers (ASME)
- International Electromechanical Commission (IEC)
- American National Standards Institute (ANSI)
- Japanese Industrial Standard (JIS)
- American Institute of Steel Construction (AISC)
- British Standards (BS)
- Association Franchise de Normalisation (AFNOR)
- Crane Manufactures Association of America (CMAA)
- International Organization for Standards (ISO)

All gears and geared parts shall comply with the metric gear standards of ISO. The Contractor may offer alternative standards, materials or equipment provided that they shall be comply with the above stated standards in all respects. In case the Contractor wishes to offer such a thing, he will notify the Owner of his reason of offer and he will submit the standard that he offers to apply to the Owner for approval.
4.10.1.2 Units
Metric ISO units shall be used.

4.10.1.3 Power Source
Power shall be of 3 phase, 3 conductor 400-230 V AC type. Motor control circuit voltage shall be 110V.

4.10.1.4 Name Plates and Tonnage Plates
All control panels, boxes, main switches, and circuit breakers shall have a three (3) folded plastic name plate with the name engraved on it. Letter size shall be 10 mm. The plate shall be white whilst the letters are black. Any abbreviation to be used on the name plates is subject to prior approval of the Owner.

Tonnage plates in metric tones shall take place on both sides of the crane. The letters and numbers on the tonnage plate shall be cut out from steels and they shall be spot welded on the girder. The letters and numbers on the tonnage plate shall be sized to read them from the floor.

4.10.2 Definition
4.10.2.1 Scope
These technical specifications comprise the design, material supply, manufacture, transportation to the site, erection, testing and commissioning of the below mentioned cranes with their auxiliary equipment, that will be used in the MUVUMBA Hydraulic Power Station.

Quantity Type

- 1(one) Overhead travelling crane having a lifting capacity of 15 tons and a span of 7.0 m.
- 1(one) Tailrace gate Monorail hoist having a lifting capacity of 5 tons.
- 1(one) Spillway Stoplog Monorail hoist having a lifting capacity of 5 tons.
- 1(one) Intake Maintenance Monorail hoist having a lifting capacity of 5 tons.
- 1(one) Diversion Box Culvert Chamber Stoplog Monorail hoist having a lifting capacity of 5 tons.
4.10.2.2 General Specifications

All the equipment shall be suitable for disassembly, inspection and erection. To facilitate site erection works, marking shall be done at necessary places. All the equipment shall have strength to be in service for a long life time, and shall have necessary auxiliary equipment even if it is not mentioned in the contract.

The material to be selected for the crane shall be brand new, in compliance with the standards and of the best available quality. First class workmanship shall be used in the manufacture of the crane.

Welding works shall be performed using electric arc welding and shall be free from slags, cracks and defects. Welding process shall be carried out in accordance with AWS, ASTM or equivalent standards.

Induction motors shall have an insulation class of F and a protection class of IP54 as per IEC34-5. Induction motors shall be of completely closed type and be able to continuously operate at 50 HZ frequency under ± 10% voltage deviations. Against big deviations in voltage that may occur due to large scale load deviations in the plant (for example: load rejection), feeding of the crane shall be controlled by minimum and maximum voltage relays.

Magnetic contractors to be used in various switches shall be manufactured from arc resistant material and shall be able to withstand the motor start-up current.

The limiting switches shall be completely closed and heavy duty type. All limiting switch contacts shall be able to safely cut the current.

The equipment and parts which are necessary for the crane but not manufactured by the contractor shall be bought from well-known and reliable companies to be approved by the owner.

All the equipment shall be so designed and erected that no vibration and therefore no harmful dynamic forces will be created when the equipment is started up, in motion or at rest. This specification prevails for all operating conditions.

4.10.3 Submittals

4.10.3.1 Drawings

Contractor’s all lay-out and detail drawings, engineering and design calculation reports shall be submitted to the Owner for approval. These drawings and reports shall comply with the clauses and aim of these specifications.

Contractor’s drawings and design calculations reports shall be prepared so that they will give
full details of design standards, arrangement style and shall include the following subject at
the least:

Mechanical drawings:
  • General lay out and arrangement plans
  • Crane bridge -trolley construction drawings
  • Mechanical erection drawings
  • Constructional detail drawings
  • Mechanical detail drawings
  • Material lists and calculation reports
  • Other data

Electrical Drawings:
  • Single line diagrams
  • General lay out and arrangement plans (shall include physical positions and views
    of motors, panels and limiting switches.
  • Plans and sectional views of cable trays and cables
  • Diagrams of the connections inside the panels
  • Diagrams of the connections among the equipment
  • Cable -piping list
  • Earthling drawings
  • Erection drawings
  • Material lists and design calculations
  • List of name plates

4.10.3.2 Design Calculations

Foundation Load: Calculations of the loads that are transmitted from the bridge to the
concrete structure when the crane lifts the maximum allowable load shall be carried out by
the Contractor and a summary of the calculations shall be submitted to the owner.
Dimensions, weights, etc: The Contractor shall confirm the calculations, dimensions, weights, etc. that are given in the offer as approximate and if needed he will re-submit after correction. This case is not applicable to the figures guaranteed in the offer given as per the specifications.

Strength Calculations: Strength calculations of the main parts of the crane shall be submitted to the Owner for inspection together with their drawings. These calculations shall, at the least, include the calculations for the crane bridge, wheels, bridge and trolley rails, drums, gears, shafts, steel wire ropes, hooks and motor capacities. Prior to submission of the documents, the contractor shall submit to the owner a list showing the names and number of the documents to be submitted.

4.10.3.3 Procedure

All the documents shall be submitted as 3 copies before manufacturing the equipment. Within 30 days after submission of the documents, one copy shall be returned to the contractor as having notes on them like ‘approved’, ‘approved expect as noted’, ‘not approved’.

After approval of the documents, the contractor shall submit 1 (one) transparent copy to the Owner.

Responsibility of any manufacturing or civil work which is performed before the approval of the documents by the Owner shall be taken by the Contractor.

4.10.4 Specification

4.10.4.1 Power House Overhead Travelling Crane

The below mentioned equipment, works and services are in the scope of this specification and they shall be provided by the contractor:

1(one) overhead travelling crane with a lifting capacity of 15 tons.

1(one) set of rails for the crane long travelling, inclusive the necessary clamping and fastening materials.

1 (one) set of busbars; inclusive their carrying and fastening systems

Spare parts

NOTE: Lifting capacity shall be decided after the generator work is awarded (see the important note on the first page)

These specifications cover the design, material supply, manufacturing, workshop assembly
and tests, painting, transportation to site, erection, site tests, commissioning and guaranteeing the above mentioned equipment and other parts.

4.10.4.2 Monorail Crane of Draft Tube Stop Gate

The below mentioned equipment, works and services are in the scope of these specifications and they shall be provided by the Contractor:

1 (one) monorail crane with a lifting capacity of 5 tons.

1 (one) set of energy cable and cable drum or suspension system for the monorail crane

1 (one) carrying beam (steel) for monorail crane, its anchorage bolts and fixation elements,

Spare parts.

Design, material supply, manufacturing, workshop assembly and tests, painting, transportation to site, erection, site tests, commissioning and guaranteeing of the equipment mentioned in the above clause and other parts.

4.10.5 Design Condition

4.10.5.1 Power House Overhead Travelling Crane

The overhead travelling crane which is the subject of these specifications shall take place in the power house of the MUVUMBA Hydro Electric Station and it will be used for erection, dismantling, repair and maintenance works of the power plant equipment.

Although the crane will be operated intermittently, it should be considered that from time to time the crane will be operated for a long period and continuously.

The overhead travelling crane which is the subject of these specifications shall take place in the power house of MUVUMBA Hydro Electric Power Station and it will be used for erection, dismantling, repair and maintenance works of the power plant equipment.

Although the crane will be operated intermittently, it should be considered that from time to time the crane will be operated for a long period and continuously.

B. Technical Data

Main characteristics of the equipment to be supplied by the Contractor shall be as follows:

Main Dimensions:

- Type: Control stick operated (without operating cabin) overhead travelling crane
- Number of hooks: 1
Detailed Design for Muvumba Multipurpose Dam

- Lifting capacity: 15 t
- Span between rail centers: 7.5m
- Longitudinal travelling distance: 16.0m
- Elevation of the beam carrying the rails: EL.1384m
- Maximum portal height: 7.5m

Speeds:
- Min. Max.
  - Hoist operating speed at full load: 3.0 m/minute (variable)
  - Bridge travelling speed: 20 m/minute (variable)
  - Trolley travelling speed: 10 m/minute (variable)

Since the crane will be required to travel at creep speeds and in short distances during erection of the equipment, it shall be possible to have various speeds in the above given minimum ranges.

Short Movements
- The hoist be able to perform at least 5 mm long smooth vertical movements.
- Maximum Deflection
- The crane bridge shall be designed for a maximum deflection of 1/800 of the span under maximum load.

4.10.6 Structure and Materials

4.10.6.1 Power House Overhead Travelling Crane

Material

Material of the steel structure shall comply with ASTM (American Society for Testing Materials) or equivalent acceptable by the Owner.

Loads And Stresses

All design calculations and works shall be based on “C.M.M.A. Spec. 70” or “FEM Rules for the Design of Hoisting Appliances” or equivalent standards.

On the basis of ultimate strength of the material, factor of safety(*) shall be as follows:
For all mechanical parts and steel wire ropes:

\[
\text{Factor of safety} = \frac{\text{Allowable stress of the material}}{\text{Applied stress (at nominal load)}}
\]

(*)

Minimum Thickness of Steel Plates

In load-carrying parts, minimum thickness of steel plates shall be 6 mm. For girder, other beams, flanges and webs, minimum plate thickness shall not be less than 8 mm.

Description of Equipment

Crane Bridge

The crane bridge shall be manufactured as welded box girder construction. Both of the carrying beams shall have identical cross sections. Axis of trolley rails shall be on the axis of bridge girder and in the calculations it will be assumed that the rails shall not carry load.

The bridge beam shall be rigidly erected to withstand vertical loads. The bridge shall, in their ends, be safely strengthened by additional plates to project the form of bridge especially during acceleration and deceleration.

The bridge beam shall be rigidly erected to withstand vertical loads. The bridge shall, on both sides, be equipped with minimum 400 mm wide walkways to be manufactured from chequered steel sheets. The walkways shall be provided with 1 m high inner and outer tubular steel handrail. Trolley rails shall take place on the bridge for travelling of trolley. Access from bridge to trolley and from walkway to bridge shall be via stairs which shall be equipped with handrails and plinths.

Maintenance platforms shall be provided for maintenance of crane wheels and access to current collectors.

Trolley

Chassis of the trolley shall be manufactured as welded steel construction. The chassis shall be so rigid that the wheels shall be equally loaded and undesired damages will not occur at the wheels. The trolley shall be equipped with a platform completely surrounded by handrail. Stairs shall be provided for access from platform to bridge.

Hoist Unit

The hoisting mechanism shall comprise the electric motor and gear set to be mounted on the trolley chassis in order to lift the load at a foreseen speed.

The lifting motor brake shall be so designed that when the motor is de-energized, it will fix the load and prevent the load from slipping down.

Motor brakes shall have standard shoes or disks and it shall be possible to adjust the brakes.
Braking torque figures shall be determined considering CMMA standards or equivalents.

Motors of brake energy feeding and protection system shall be independent.

All brakes shall have manual relieving mechanism.

Electrical drive unit shall be continuous duty type.

Brakes shall be mounted on the motor shaft.

Brake flywheel can be a complete unit including the coupling.

Brake flywheel shall be manufactured from sphere-cast ferrous material.

Travel of Crane

Travel of crane shall be controlled via a control stick with push buttons on it for any desired mode of motion, braking and stopping of the crane.

The mechanism that will actuate the trolley shall be mounted on the chassis of trolley and motion of the drive motor will be transmitted to the trolley wheels via a reduction gear system. All the wheels shall have double flange. On each rail, number of drive wheels shall not be less than 25% of total number of wheels on that rail.

Brake system of the trolley’s drive motor shall be equipped as the brake system of the lifting motor.

Rigid buffers having a height not less than half of diameter of drive wheels shall take place on both ends of the trolley rails. The buffers shall be fixed to the bridge beams, but not to the rails.

The bridge will travel by means of the gear, shaft, reduction gear system and the driving wheels to be provided at both ends of the bridge. Brakes to be provided for the driving system of the bridge shall be controlled by the remote control push button stick to vent the brake air.

The wheels shall be of double-flanged type and manufactured from cast steel. On each rail, number of the drive wheels shall not be less than half of the number wheels on that rail.

Rigid buffers having a height not less than half of the diameter of drive wheels shall take place on both ends of the bridge rails. The buffers shall be designed for stopping the crane when it is travelling at full speed and no-load condition. The bridge rails shall take place on reinforced concrete beams. Together with the rails the contractor shall also provide the anchorage plates that will ensure distribution of crane wheel loads on the concrete beams within the allowable stress value of 50 kg/cm². Also, the bolt sand nuts that will ensure fastening of these plates other ails shall be provided by the Contractor.
4. Mechanical Specification

Control Stick

A remote control push button stick shall be provided in order to actuate the travelling, hoisting and braking system of the bridge, trolley and hoist unit, as specified in the related clauses of these specifications. The control stick shall suitably be suspended from the bridge and it shall not restrict the motions of the bridge and hoist unit. The control stick shall be approximately 1.0 m above the ground level to perform the control commands easily.

Mechanical Parts

Steel Rope Pulleys

Steel wire rope pulleys shall be manufactured as either cast steel or welded construction. Diameter of the pulley section onto which the rope is wound shall not be less than; 30 times the other rope diameter for moving pulleys and 24 times the outer rope diameter for stationary pulleys. Pulley pegs shall be manufactured from high quality alloy steels and antifriction bearings shall be used.

Wheels

Wheels of the bridge and trolley shall be manufactured from cast steel, be double-flanged and equipped with antifriction bearings. Material of the wheels shall comply with ASTM A-27 Grade 6-30, and its strength shall comply with ASTM A-418 standard.

Drum

Lifting drum shall be manufactured as either cast steel or welded construction and all of its surfaces shall be machined.

The drum shall be so mounted that it will distribute the load to the two beams equally. Steel rope grooves shall be right and left oriented helical. The drum shall be selected so big that it will be possible to wind the whole rope without having one part on top of the other part of it, and when the hook is at its lower limit position there will 2 complete wounds of rope at the two ends of the drum. Diameter of the drum section onto which the steel rope is wound shall not be less than 22 times the outer rope diameter. A 4 mm thick tolerance shall be left for remachining of the worn grooves on the drum. The drum gear shall rigidly be fixed to the drum in order to eliminate the torsional stresses in the drum shaft. The drum shaft shall be a continuous one between the bearing, stud shaft shall not be accepted.

The drum shall be so mounted that it will distribute the load to the two beams equally.

Hook Block

The hook block shall comprise the pulleys, suspension plates, shaft, axial bearings and hooks. The hook shall be of double mouth type and it will be easily turned around its roller bearing under maximum load. The hook shall be of a single piece, and made of wrought and heat treated alloyed or carbon steel.
Steel Ropes

The ropes to be used shall be made of hardened and tempered steel wires, they shall be normally wounded. Length of the ropes shall be such that when the hook is lowered to its lowest position, at least two wounds of rope shall be left on the drum in order to fix the rope to the drum. For selection of rope, the safety factor shall, on the ultimate strength basis, be taken as 5.

Gear System

The gears to be used shall be of worm gear, spur gear and herring-bone type. Herring - bone and spur gears shall be manufactured as standard helical type.

Worm and pinion gears shall be manufactured from tempered and hardened carbon steel or alloyed steel. Spur gears shall be manufactured from tempered and hardened steel or cast steel, and the teeth shall be manufactured by machining. Necessary heat treatment shall be applied before the teeth are machined. Worm gear shall be manufactured from bronze of suitable quality.

The teeth operate smoothly and the temperature at any point of the teeth shall not exceed 75°C.

Surface stresses shall be selected as small and no wear shall be observed at the end of the one year guarantee period.

Gear boxes shall be of completely closed and oil-leak tight type, they shall have an oil leak tight cover with gasket at the top, lube oil filling port, air vent, discharge tap, tube oil, I felt on input and output shafts, level indicator, lifting clamp and bearing housings. The foreseen design shall aim lube-oil tightness and tube-oil tightness shall be guaranteed.

Support of the gear boxes shall be strong and no load transmission will occur from these supports to the gear boxes. All gear boxes shall be manufactured as welded steel construction or cast steel. Welded constructions shall be subjected to heat treatment before machining.

Shafts

To conform to the bearings and gears, all shafts be carefully machined and sufficiently supported against deflection. The deflection that may occur between the bearings shall not exceed 0.8 mm/m.

The shafts shall be made of tempered and hardened steel and they shall be fastened to the gears by keys.

Bearings

The bearings shall be antifriction type cylindrical, spherical roller bearing or journal bearing with bronze housing. All bearings be easily disassembled from the shaft and they shall be
equipped with suitable lubrication system considering their type.

Bearings of the bridge carrying system shall be interchangeable. Shaft bearings shall be so placed that they will be as close to the loading side as possible.

All bearings shall operate inside a lube-oil tight housing to be protected against dust, dirt, etc.

Lubrication

All gears and pinions operating at high speeds shall be lubricated using lube-oil bath method and all gears operating at low speeds shall be soft greased.

To easily access lubrication fittings, copper lubrication pipes shall be used and they shall be firmly fixed.

Buffers

Not to cause any destruction the bridge and trolley shall be equipped with spring type buffers to ensure their safe stopping when they reach the end of their horizontal motion. One buffer shall be mounted in each of 4 corners of the bridge and trolley. Buffers shall comprise head, cylinder, suitable spring systems and accessories and they shall be firmly fixed to the bridge front beam and the trolley chassis. In front of each buffer and rails, the stopping buffers to be made of cast steel or steel construction, shall take place.

The buffers shall stop the bridge at a deceleration of 1 m/s² while the crane is travelling at no-load condition and at a speed equal to 20% of its full load speed.

For the trolley, average deceleration shall be 1.3 m/s².

Moving Parts

It shall be possible to disassemble all the wheels and wheel blocks as independent from other wheel groups.

It is necessary to design and manufacture the transmission elements such that they can withstand excessive loads that may be created due to distortion of wheels resulting from collision.

To withstand the worst conditions that may occur during travelling, the transmission elements shall have an excessive loading capacity of at least 25%. During disassembly of the crane wheels for maintenance, attention shall be paid not to cause excessive loading on or moving of the carrier by lifting the carriers using jack. The jacks shall be portable and they shall not be placed on the crane.

Couplings

Bolts of all couplings shall be open

When heavy duty or excessive heavy duty type power transmission is to be realized, gear or
flexible type coupling shall be used.

Electrical Equipment

General Conditions

Electrical equipment shall be designed for 400+10% V voltage and 3 phase current system.

Panel

The panel shall be manufactured from steel sheet, it shall be dust and insect-proof and easily aerated. The panel shall be protected against corrosion by painting from inside and outside. The panel shall be designed as to allow easy inspection of electrical equipment. A thermostatically controlled heater shall be placed inside the panel.

Connecting System

Connecting system shall be orderly arranged and fixed by necessary number of supports. Cable colors shall be selected as per color codes.

LV Breaker Contactors

They should be reliable and quick response type. Necessary magnetic and thermal protections shall be provided for the breakers. This protection shall be realized in the primary circuit and it shall provide a complete selectivity.

Auxiliary Contacts

Circuit breakers, contractors, etc. shall be equipped with contacts whose number shall be sufficient for control, signal, locking and releasing.

Resistances

The resistances shall have the long term current carrying capability. To prevent excessive heating, they shall be manufactured and erected as having a great heat transfer area, they shall be metallic and cooled with natural air circulation.

Limit Switches

The limit switches shall be automatic set, completely closed, and heavy duty type, also they shall have adjustable limit contacts.

The limit switch shall cut the feeding current of motor thus it will ensure safe stopping and braking of moving parts at their limit points, however it will allow to move towards the permissible zone.

Sufficient number of limit switches shall be used for motions of the bridge, trolley and hoist and crane operator shall be warned by an audible signal when the limit point is approached.
Earthling

Electrical equipment parts such as covers supports, etc. shall be earthed via the crane rails using braided copper conductor (connection included) having a minimum cross sectional area of 16 mm$^2$. Necessary arrangements shall be provided for earthing each rail from its two ends to the plant main earthing system. The main earthing system shall be constructed by another contractor and the earthing cables shall extend up to the earthing terminal of the equipment.

Current Collectors

The crane shall be energized via V-busbars and for each phase busbar through two shoe collectors. Cables necessary for the trolley’s travel shall be carried in a system with suspension pulley (festoon). Collectors, busbars, busbar insulators and other necessary metallic connections shall be provided by the Contractor.

Motors

Drive motors shall be completely closed, asynchronous type, shall have IP54 protection class and F type insulation. It shall be able to operate for 60 (sixty) minutes continuously and to meet the other requirements.

Motor bearings shall be spherical roller type.

Lighting

For erection, four (4) lightning bulbs (220 V, 500 W, reflector bulb) shall be mounted underneath the crane and it will be possible to change the bulbs easily.

Breaking Switches

In the power house, there shall be a fuse less breaking switch for the main energy circuit. The breaking switch shall be mounted inside a NEMA-1 panel or equivalent.

Cabling and Cable Pipes

Supply and erection of cables and cable pipes shall be in accordance with NEMA, NEC and IEC standards.

For maintenance and repair purposes, there shall be three (3) plug-socket set on the crane bridge. The sockets shall be outdoor type, double wired, three pole and shall have spring-operated cover. All power and control cables shall be laid in separate cable pipes and an electrical insulation collar shall take place at the end of cable pipes.

All cables shall be laid in thick wall galvanized steel pipes. As far as it is possible the cables shall be supported inside the cable pipes.

All cables shall be made of multiple wire copper conductor. Cable section shall be 2.5 mm$^2$. 
Detailed Design for Muvumba Multipurpose Dam

at the least or in accordance with BS14. All cables shall be in accordance with the voltages 600/1000, and color codes shall be applied control for cables.

Erection marks shall exist in all circuits distributed for packing.

All cable ends shall suitably be labeled, cable and related circuit no.’s shall take place on the labels.

Pulling boxes shall be used instead of fittings for cable pipes. Pulling boxes shall be put also at connection points of electric to be connected during erection.

Cables shall be fastened to the pipes by clamp latch from inside and outside of the box.

Erection Method

All electrical equipment shall be so placed on the bridge that they can be easily accessed, cleaned, lubricated, changed and maintained.

Reliability and continuity shall be given prime importance in operation of the crane.

All electrical equipment shall be so fixed and supported on the crane that they shall not be affected by the loads that may occur on the crane during operation.

Electrical equipment shall not be placed under gear boxes, and in the places which are not accessible for maintenance and where there is a risk of fire such as oil dripping parts.

Erection

The crane parts shall be workshop erected to the utmost possible extent and suitable for transportation.

4.10.7 Painting and Mark

The contractor shall take all the measures to protect the equipment against corrosion. Prior to painting works, the Contractor shall submit a painting plan including paint colors, quality, painting period and method to the owner for approval. All manufactured parts shall be cleaned from corrosion, oil, dust, etc. by sand blasting or other methods and then priming shall be applied. Priming shall be applied as 2 layers. Final painting work of all open surfaces of the equipment shall be performed using synthetic resinous paint. Final painting shall be performed as 2 layers the first of which shall be applied in the workshop whilst the 2nd layer shall be applied at site. All equipment and material necessary for cleaning the surfaces and painting shall be provided by the Contractor.

Electrical equipment (motors, panels, etc…) shall be painted by spray paint and they shall be brought to site as painted. However, against possibility of repairs, a sufficient amount of spare paint shall be available at site.
4. Mechanical Specification

The performed painting works shall be guaranteed for 5 years.

Painting works shall not be performed under the following conditions:

1-When the air temperature is below 5°C

2-When the air temperature and humidity are excessively high

3-If there is the possibility that it may rain before the paint completely dries.

4-If there is possibility that air bubbles may be created on the painted surface under the effect of sunlight.

Minimum 20 micron thick undercoat and white epoxy polyamide or an equivalent paint shall be applied to the inner surfaces which are in contact with oil.

Final layer paint colors shall be as follows:

- Trolley collector angle irons, hook blocks, all handrails, buffers of the crane and trolley shall be painted by yellow color paint.

- Yellow and black color bands shall be applied on the outer surface of operator’s cabin from bottom up to 500 mm height.

- After final painting, yellow and black color bands (45 °C inclined and 75 mm wide) shall be applied on the outer surface of carriers.

- All gear boxes shall be painted with red paint.

4.10.8 Shop Test and Inspection

The Contractor shall perform the below mentioned tests as per the specifications, all costs of inspections and tests shall be included in the contract price. The Owner’s representatives shall witness the manufacture and workshop erection of crane parts. All equipment and measuring devices necessary for workshop and site tests shall be supplied by the Contractor.

**Workshop Tests**

All material which are subject to considerable stresses shall be inspected by ultrasonic method. All welds shall be subject to visual inspection. All intersection points and suspected parts shall be x-ray tested. The parts that will be x-ray tested shall be determined by the Owner.

In the workshop, the crane shall be manufactured to the possible extent, its appearance, workmanship and dimensions shall be inspected. Electrical equipment shall be fixed as per the standards. Hoist shall be tested at no-load condition. Limit switches and control panel shall also be tested. To minimize the site works, all adjustment works shall be performed in
Workshop inspections and tests shall be witnesses by the Owner’s representatives and a report shall be prepared on the performed works.

4.10.9 Spare Parts

4.10.9.1 Power House Overhead Crane

The Contractor shall supply the below mentioned spare parts:

- Brake disks 1 set from each type
- Carbon brush 1 set from each type
- Main contact 1 set from each type
- Coil 1 set for contactors and relays
- Auxiliary contact 2 blocks from each type
- Signal lamp 2 sets
- Other necessary parts

4.10.10 Test

4.10.10.1 Power House Overhead Crane

Aim of these tests is to check the performance and operating characteristics. The Contractor shall supply all equipment and loads necessary for these tests. Upon completion of erection of the crane, the crane shall be subjected to the following tests in the presence of the Owner’s representatives:

Visual inspection and dimensioning check of the equipment

Static Excessive Load Test

When the hoist at the middle axis of crane, it will be subjected to a static test applying a load which is equal to 125% of nominal capacity. The guaranteed deflection and general condition of the crane shall be checked. The load shall be suspended for one hour, then it will be reduced gradually. After all of the load is rejected, the crane shall be checked for any permanent deflection.

Dynamic Excessive Load Test

A load that is equal to 125% of the nominal capacity shall be suspended to the hook and
then lifting, lowering, trolley and bridge travel checks shall be performed. This test shall uninterruptedly last for \( \frac{1}{2} \) hours. After the load is taken out, the trolley and bridge shall be checked for any damage and the mechanism shall be checked for excessive heating.

Dynamic Test Nominal Load

The following tests and checks shall be performed when the nominal load is applied at the hook:

- Permanent deformation or excessive heating
- Effectiveness of the brakes and limit switches
- Sliding of the wheels on the rails as the travel starts and during braking
- General stability of the load carrying system
- Operational speeds
- Satisfactory operation of safety devices and other accessories
- Smooth, vibration-free, uninterrupted motions and sensitive response to the control commands
- Braking and stopping ranges
- Control system and brakes shall ensure 5 mm long vertical movements of the hook under full load condition
- Excessive heating of bearing and other mechanical parts (75°C shall not be exceeded)
- Satisfactory operation of the controls and other electrical equipment.

**4.11. Steel Penstock**

**4.11.1 Description**

One complete lane of the steel penstock, 1700 to 700 millimeters in diameter by approximate 128 meters in length, small be designed, furnished and delivered by the Contractor under this Contract.

The penstock shall be complete with straight pipes, bend pipes, branched pipes, bifurcation, stiffener rings, thrust collars, drain pipe with valves, anchor bands and bars and all other necessary component. The penstock extend from penstock tunnel to the main inlet valves of the water turbines.

The all penstock shall be encased in concrete. The installation of penstock and the concrete
placing will be performed by the Employer (other Contractor).

The layout and arrangement of the penstock with accessories shall be as shown on drawing.

### 4.11.2 Design Condition

#### 4.11.2.1 Design Loads and Conditions

The main pressured portions of the penstock shall be designed in accordance with Technical Standards for Gates and Penstocks of best modern practices and the following conditions:

To resist the internal pressure as given on Drawing of “DESIGN HEAD DIAGRAM”.

The internal pressure shall be of sum of the static head and the pressure rise, which are defined as follows:

- **Static head** is the difference between the centerline elevation of the penstock and the high water levels at the intake.

- **Pressure rise due to water hammer**

  The pressure rise due to the water hammer shall be 17 meters for operation under HWL 1405.0 meters at the centers of the water turbines, and the rise is assumed to change gradually along to the penstock centerline, as shown on Drawing.

  To resist the external pressures

The parts of penstock shall be encased in concrete and be capable of resisting the following external pressures when the penstocks empty.

- **The factor of safety against buckling shall not be less than 1.5.**

At the embedded portions

The external pressures at the embedded potions of the penstocks shall be as shown on Drawing of “DESIGN HEAD DIAGRAM”.

To resist the external pressure due to contact grouting.

The penstocks where embedded in horizontal portions shall be capable of resisting the external pressure due to contact grouting between pipe shells and secondary concrete. The pressure of grouting for designing the penstocks shall be of 1.0 kg/㎠.

To resist the axial forces

The penstocks shall be capable of resisting the axial forces. The considerable axial stresses
shall be as follows:

Bending stress due to expansion restraint of pipe shells by the stiffener rings and anchor block,

Stress due to axial component of internal pressure at the reducing pipes, and

Stress due to falling of temperature in the penstock, when water filling. The falling of temperature will be 20 degrees C.

To resist the loads due to handing during fabrication, transportation and field erection.

The shell thickness shall not be less than the thickness necessary for handling, as determined from the following empirical formula:

\[
t = D + \frac{800}{400}
\]

Where \( t \): minimum plate thickness of pipe shell (mm)

\( D \): inside diameter of penstocks (mm)

The steel penstocks shall be capable to reduce hydraulic friction losses in the penstocks to a minimum. The maximum deflection angle between segments of a bend shall not exceed 7 degrees. Under such inevitable cases as right angle bend pipes, bifurcating pipes, and the like, The radius of curvatures of the pipes may be more than 2 times of the inside diameters of the pipes. All welds of interior plate surfaces shall not project above the adjacent plates, and where the adjacent plates are not in line shall the weld be furnished off to form a smooth transition between the surfaces.

### 4.11.2.2 Design Stresses

#### Steel Materials

The allowable stresses for normal loading of steel materials shall be as follows:

<table>
<thead>
<tr>
<th>Steel Material</th>
<th>Tensile stress (Unit: kgf/㎠)</th>
<th>Compressive stress (Unit: kgf/㎠)</th>
<th>Shearing stress (Unit: kgf/㎠)</th>
<th>Bearing stress (Unit: kgf/㎠)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SM400</td>
<td>1,200</td>
<td>1,200</td>
<td>700</td>
<td>2,000</td>
</tr>
</tbody>
</table>

In case that the penstock is fully with water:

The circular stress, axial stress and the perpendicular stress against the axis of the pipe and
the combined stress for normal condition shall be less than the allowable stress as above-mentioned. However, in case of addition of the bending stress on the pipe shell caused by the stiffener rings, the allowable stress shall be 1.35 times the allowable stress for normal loading.

The combined stress shall be calculated by the following formula as developed by Mises Hencky Huber:

$$\sigma_g = \sqrt{\sigma_1^2 + \sigma_2^2 - \sigma_1 \sigma_1 + 3 \tau_2} \times 0.5$$

where, $\sigma_g$: combined stress (kg/㎠)

$\sigma_1$: circular stress (tension is taken as positive, kg/㎠)

$\sigma_2$: axial stress (tension is taken as positive, kg/㎠)

$\tau$: shearing stress (kg/㎠)

In case that the penstock is water-filling:

The circular stress shall be less than 1.5 times as the allowable stress for normal loading.

Concrete Bearing Stress

The concrete bearing stress shall not exceed 50 kilograms per square centimeter.

4.11.2.3 Welding Efficiency

The strength of the longitudinal and girth welds of the steel penstocks shall be rated at 95 per cent of the plate strength at the workshop and field shop and at 90 per cent at the erection site.

4.11.2.4 Welding Joints

Full penetration butt-weld joints shall be used for all longitudinal and girth welds in the penstock shells, except for adjusting pipes.

4.11.2.5 Corrosion Allowance

A thickness of 2.0 millimeters as a corrosion allowance shall be added to the calculated shell thickness for internal and/or external pressure.
4.11.3 Structure and Materials

4.11.3.1 Appurences

Bifurcation

The bifurcation shall be of wye-branch type and shall be designed to minimize the head loss in the bifurcation. The bifurcation shall be designed to withstand the pressure as described in this section clause “DESIGN LOADS AND STRESSES”. Reinforcement of the bifurcation shall be designed to minimize the high stress concentration as much as possible. Drain pipe with two stop valves shall be furnished for bifurcation as shown on Drawing.

Stiffener Rings

The stiffener rings shall be attached to the penstock perpendicular to the direction of the penstock axis and to pipe shell by continuous welding. The rings shall have staggered ribs. The structure of rings shall be such that secondary concreting around the penstock can be securely placed and air around the lower portion of the penstock can be easily released.

Grout Holes

The grout holes and pipes for the contact grout and the back-fill grout shall be provided on the penstock as shown on the Drawing.

Grouting will be performed by other contractor.

Thrust Rings

Thrust rings shall be welded to the pipes and shall have the strength sufficient for transferring axial thrust to surrounding concrete.

Seepage Rings

The penstock shall be provided with three parallel seepage rings at the beginning portion.

4.11.3.2 Fabrication

General

The Contractor shall cut the plate for the penstocks to exact dimensions, prepare the edges for welding, press the edges for rolling, roll them to the required curvatures at the Contractor’s shop, ship them to the Projects site and make them to complete sections in the field shop for installation. The steel materials to be used for the penstocks shall be clearly marked for easy discrimination of their kinds.

 Cutting and Bending

All plates shall be cut accurately to the dimensions shown on the Contractor’s approved
drawings, with allowance provided for possible shrinkage during welding. All edges shall be inspected for sound metal and be free from laminations, surface cracks and other injurious defects.

All plates may be rolled or bent to true curbed section, continuous to the edges, by any process that does not impair the strength of the plates and with continuous curvature between the edges. The plate which has been rolled or bent, will be shipped to the Project site and fabricated to the complete cylindrical shell on the field shop for installation by the Employer.

Correction of curvature by hammering will not be permitted. For butt welding of plates of unequal thickness, The work of trimming of the thicker plate shall be done in the Contractor’s shop, if the difference between plate thickness is more than 3.0 millimeters. The orientation of the plate for fabrication shall be such that the final direction of rolling is placed circumferentially. No stamping or groove marking on the penstock shell shall be allowed.

Bending of plates shall be performed by cold working as a rule. If bending made by hot working, the Contractor shall obtain the approval of the Engineer for the temperature control procedure.

Welding

In addition to the welding requirements of the General Specifications, the following shall given:

The surfaces of plates to be welded shall be cleaned of all scale, rust, oil, paraffin or grease, for a distance of not less than 25 millimeters from the welding edge.

When the penstock is completely erected ready for concreting, there shall be no lugs, cover plates, saddles or other devices welded to the penstock shell, except where these form part of the permanent support of the penstock for concreting. All temporary lugs and devices welded to the outside of the pipe-shell shall be carefully removed by other contractor and welds dressed smooth and flush with the surrounding metal. Care shall be exercised in removing such attachments to prevent cutting, tearing or gouging into the metal of the pipe shell. After concreting is completed, all internal bracings and devices welded to the inside of the penstock shall be similarly removed and the inside dressed smooth and flush.

All lugs, saddles or brackets which are welded to the penstock and which are to form part of the permanent or temporary support shall be made of the same plate material as the penstock and the welding shall meet with all the requirements as set out herein.

All welded joints shall be dressed smooth and the maximum reinforcement shall be limited to the following tolerances on the inside of the penstock. On the outside of the penstock, welds shall be dressed free of all flux and scale and smooth to the extent necessary to allow radiographic examination.
4. Mechanical Specification

<table>
<thead>
<tr>
<th>Plate thickness (mm)</th>
<th>Tolerance (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 12</td>
<td>1.5</td>
</tr>
<tr>
<td>12 –25</td>
<td>2.5</td>
</tr>
<tr>
<td>Over 25</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Thrust rings, seepage rings and stiffener rings shall be welded on the pipe shells at the Contractor’s workshop or field shop as a rule.

Core wires, fluxes and welding rods shall be of the most suitable materials for the base metals and shall be kept under sufficient dry condition. The Contractor shall obtain the approval of the Engineer for their kind, characteristics, weldability and control procedure.

Type of welded joint of the pipe shell shall be the butt joint except adjusting joints.

Back chipping for welded joint shall be performed by arc-air gouging.

Tack welding on the pipe shells shall not be made as far as possible. If the tack welding is made, the welded portion shall be preheated at more than 100°C for a distance of not less than 50mm from the welding line to reduce the residual stress.

Welded joints shall be preheated in accordance with kind of steel materials and plate thickness. However, maximum interpass temperature shall be 200 degrees C and preheated area shall be a distance of more than four times the plate thickness from the welding line.

The procedures to be engaged in the production welding of the penstocks shall be described in concrete details by the Contractor and shall include the following information. The procedures shall be submitted to the employer for approval.

- Welding process (e.g. manual arc welding, automatic submerged arc welding, etc.).
- Material specification and the range of thickness to which the procedure specification applies.
- Joint design (angle and size of bevel, root opening, backing strips or bars if used, est.).
- The maker and brands of electrodes and fluxes and the nominal composition of filler metal and shielding gases.
- Size and type of electrodes, approximate number of runs, size of electrodes used for each run and sequence of runs.
- Electrical characteristics (current and polarity, and the range of voltage and amperage).
- Welding position.
• Preheating and post-weld heat treatment (method of heating, temperature range and methods of control).

• Other information to be recommended by the Contractor.

Postweld Heat treatment

Welds shall be postweld heat treated in accordance with the applicable code requirements including required holding temperature, time cycle and heating and cooling rates. The code requirements for postweld heat treatment shall conform to ASME Section VIII, Paragraph UCS-56 and ANSI B31.1 Table 131, “Preheat and Postheat Treatment of Welds Exclusive of Boiler External Piping,” as applicable. Code allowed exemptions to mandatory postweld heat treatment requirements shall be subject to Purchaser’s review with attention given to appropriate additional preheat requirements. Additional general requirements for postweld heat treatment are as follows:

Where members being joined are of unequal thickness, the nominal thickness of the weld heat affected zone in the heavier section shall be the governing thickness for determining the holding period duration and the heating and cooling rates.

A complete automatic temperature record shall be made of all postweld heat treating operations.

For furnace heat treatment, thermocouples shall be attached directly to the component. A sufficient number of thermocouples shall be used to ensure temperature uniformity.

The following requirements shall apply to local postweld heat treatment only:

• All welded joints in piping 100mm nominal size or larger shall be heated by electric induction or resistance methods.

• The minimum heated bane width for induction or resistance heating shall be 5 times the thickness of the thickest component, but not less than 50mm from the weld toe on each side of the weld.

• All marking fluid, chalk, tape, tags and other materials deleterious to materials during thermal treatment shall be removed prior to postweld heat treatment with Purchaser approval.

• Welded joints of carbon steel where the nominal thickness of the heaviest material being joined is 25mm of greater shall be stress relieved, upon completion of the welding operation, provided that the qualifications tests of the welding process meet the Charpy requirements of 2.8 kgm at 0°C.
4. Mechanical Specification

4.1 Tolerance

The completed penstock shall conform to the dimensions shown on the drawings and to the tolerances specified herein. The tolerances of circumferential of each section shall not exceed plus or minus 0.1 percent of the design length for that section. The tolerance at minus side for plate thickness shall be less than 0.5mm.

The end of cylindrical sections shall be within tolerance of plus of minus 2.0 millimeters of the plane normal to the axis of the sections. Angles of bends shown on the approved drawings shall be within a tolerance of plus or minus 10 minutes of angle. The pipe shells shall be aligned so that their centerlines are within plus or minus 5.0 millimeters of the true centerline as showing on the drawings. The tolerances listed are exclusive of any allowance for shrinkage or distortion provided by the Contractor to compensate for effects of welding.

4.11.4 Shop Test and Inspection

4.11.4.1 Mill Tests

The steel plates for the penstock shall pass the following mill tests in accordance with the requirements of the Japanese Industrial standards (JIS) for each thickness and each quality or approved equivalent standards.

Tension test,
Bend test,
V-notch charpy impact test, and
Chemical analysis

Certified copies of mill test reports shall be furnished to the Engineer in quintuplicate as soon as possible after the tests are made. The results of the test shall be in a form that provides means of determining compliance with the applicable specifications for the materials tested. When requested, all tests or trial shall be made in the presence of the authorized Inspector appointed by the Employer.

4.11.4.2 Radiographic Examination

The radiographic test for bifurcation shall be done on the fully welded length.

Radiographs shall be in accordance with the requirements and technique of JIS Z 3104 and be passed over or equal to second class. Objectionable defects in welds shall be chipped by flame of arc-gouged to show sound metal and the effects re-welded. Welds that have been repaired shall be 100 percent radiographed again. The Contractor shall furnish all equipment, films and labours necessary to perform the radiographic test. All original films of the
radiographs shall become the property of the Employer. The Contractor shall provide proper storage for his radiographs and shall store and preserve all radiographs of welding, whether the welding is accepted or rejected. All radiographs shall be identified and an identification drawing shall be prepared.

The Contractor shall submit the radiographic inspection procedure for approval to the Engineer and shall obtain Engineer’s approval before the inspection is made. The Engineer shall have the right to add further radiographic inspection of the welded lines when needed.

4.11.4.3 Welding procedure Test

The welding procedure for SM50 class steel material shall pass the following procedure tests:

Shop automatic welding procedure test

Plate thickness

The Plate thickness used for the test shall be the maximum and minimum thickness only to be used for the penstock by the Contractor.

Welding conditions

The welding shall be carried out in accordance with the conditions recommended by the Contractor and approved by the Engineer. The welding conditions shall include kind of core wire and flux, preheating temperature, welding current, arc voltage, welding speed, weld heat input, groove conditions, etc.

The applied standard on these tests shall be JIS or approved equivalent standards. The Contractor shall submit the detailed plan of the above tests to the Engineer for approval.

Site welding procedure test

The Contractor shall prepare a plan for the site welding procedure test conformed to the site conditions, and shall obtain the approval of the Engineer for the plan.

Inspection

The penstock will be inspected by the Engineer on welding and surfaces imperfections such as undercut welds, stamps, clamp or chisel marks, surface pitting in the plate and other similar surface irregularities. Material which show defects subsequent to erection will be rejected and the Contractor shall be notified of it. Faulty material and workmanship shall be made good by the other contractor under the supervision of the Contractor’s supervisor to the Engineer’s entire satisfaction.

The location of all imperfections and the corrective measures taken to effect repairs shall be recorded.
4. Mechanical Specification

**Radiographic Test**

The bifurcation shall be subjected to the radiographic test for fully welded length at the Site by the other Contractor after completion of this works, prior to concrete placing. The other contractor shall provide furnish all equipment, materials and labours necessary for performing the test.

Objectionable defects in the welds found during the test shall be chipped by flame of arc-gouged to show sound metal and rewelded. Test shall be repeated on the repaired welds again until the Engineer’s satisfaction. A record of the actual results of test shall be submitted to the Engineer.

**4.11.4.4 Painting Inspection**

**Adhesion inspection**

The peeling test shall be carried out on the dried films on the pipe shells at any time during painting work.

**Pinhole inspection**

The dried films on the pipe shells shall be checked by pinhole tester for pinhole at any time during and after painting work.

**Thickness inspection**

The thickness of dried films shall be measured by elcho-meter.

**4.11.5. Installation**

**General**

The installation work including the erection, welding, field painting and testing of the penstock will be performed by other Contractor under the supervision of the Contractor’s supervisor(S). The supervisor shall carefully proceed with the installation in accordance with the schedule and the Engineer’s instructions, as the installation of the penstock is required to keep pace with the progress of related works. Prior to installation, the Contractor and other contractor shall prepare a plan for the order, method and Schedule of installation upon careful deliberation with other works, and shall obtain the approval of the Engineer for these plans.

The other contractor will be furnished all labours, materials, facilities, tools, instruments and equipment necessary for installation of the penstock except those provided the Contractor as specified in General Specification and this specifications. Concrete placing will be done by other Contractor under the Engineer’s direction.
Handling and Placing

In order to maintain the accuracy of roundness of the penstock sections within the tolerance specified, internal spiders shall be provided in the sections immediately upon completion of fabrication to prevent any deformation that may take place during transportation, installation and concreting will be performed by the other Contractor, if required.

External structural steel supports and facilities for anchorage shall be furnished and delivered by the Contractor to prevent displacement or uplift of the penstock sections due to buoyancy or external forces that may occur during placing of concrete. The supports will be encased in the concrete with the penstock. Inserted bars for supports where required in the primary concrete will be supplied and embedded by the Employer (other Contractor) in locations as shown on the approved drawings prepared by the Contractor.

Field Welding

Matching of field welding for girth joints shall be carried out with spiders plates of tackweld jigs.

In any case, penstock sections shall be forcibly jointed.

During the welding operations, the centers and distances between edge preparations shall be maintained at their proper positions.

Field welded joints shall be preheated in accordance with kind of steel materials and plate thickness. However, maximum inter pass temperature shall be 200 degrees and preheated area shall be a distance of more than four times the plate thickness from the welding edges. Suitable cover shall be provided over the pipe shells to protect from the water dropping on the welded joints for all working times for welding. Equipment for drying the welding rods shall be provided to ensure that the welders use dry welding rods at all times.

Postweld Heat treatment

Welds shall be postweld heat treated in accordance with the applicable code requirements including required holding temperature, time cycle and heating and cooling rates.

The code requirements for postweld heat treatment shall conform to ASME Section VIII, Paragraph UCS-56 and UHA-32, “Requirements for Postweld Heat Treatment of Welds Exclusive of Boiler External Piping,” as applicable. Code allowed exemptions to mandatory postweld heat treatment requirements shall be subject to Purchaser’s review with attention given to appropriate additional preheat requirements. Additional general requirements for postweld heat treatment are as follows:

Where members being joined are of unequal thickness, the nominal thickness of the weld heat affected zone in the heavier section shall be the governing thickness for determining the holding period duration and the heating and cooling rates.
4. Mechanical Specification

A complete automatic temperature record shall be made of all postweld heat treating operations.

The following requirements shall apply to local postweld heat treatment:

All welded joints shall be heated by electric induction or resistance methods.

The minimum heated band width for induction or resistance heating shall be 5 times the thickness of the thickest component, but not less than 50mm from the weld toe on each side of the weld.

All marking fluid, chalk, tape, tags and other materials deleterious to materials during thermal treatment shall be removed prior to postweld heat treatment with Purchaser approved solvent.

Welded joints of carbon steel where the nominal thickness of the heaviest material being joined is 25mm of greater shall be stress relieved, operation, provided that the qualifications tests of the welding process meet the Charpy requirement of 2.8Kgm at 0℃.

Removal of Spiders

Spiders shall not be removed without the permission of the Engineer.

Connection of Penstock and Short Distance Piece

The civil contractor shall connect the penstock by means of welding to the short pipes of the turbine inlet valves provided by the generating equipment contractor in accordance with the direction of the Engineer.

4.11.6 Water Filling Test

After completion of the entire work, a water filling test shall be performed as part of the operating, test after water filling for the generating equipment. During the test, all exposed joint and appurtenances shall be examined for leakage. Defects and leakage discovered during the test shall be promptly repaired.

4.12. Trashrack

4.12.1 Definition

Screen and all appurtenances necessary to make equipment complete and operable as indicated.
4.12.1 Scope of Work
Trashrack 1 set

4.12.2 Design Condition

4.12.2.1 Provisions
Hardware, bolts, lockwashers, and nuts: Type SS400 steel.

The bar rack shall consist of SS400 steel formed straight and true, fabricated in two or more sections and held firmly and accurately in place by means of weld spacers at each end.

Install the bar rack and dead plate vertically with no inclination except the lower portion of the rack which shall be inclined slightly per the manufacturer’s recommendations.

Construct the bar screen section to be readily removable in convenient sections.

4.12.2.2 Design Data
Trashrack
Trashrack : Fixed Steel Bar Screen
Size : W4.5m × H4.5m
Bar Spacing : 75mm
Material : SS400
5. Electronical Specification

5. Electronical Specification

5.1 Electrical Construction Specification

5.1.1 Installation works of electrical facility

5.1.1.1 Scope
This specification shall be applied to installation works of electrical facility if electrical, measurement and control works.

5.1.1.2 Reference Standards
All equipment systems supplied under this Contract shall conform to the latest editions of the IEC (International Electrotechnical Commission) Standards or equivalent Iraq or other International Standards, provided they promise to confirm equal or superior performance. If standards other than IEC are referred, then the Bidder shall enclose English version of the standard with the bid.

5.1.1.3 Description of the Works
Installation, assemblage, or adjustment of equipment shall be executed after enough examining a design drawing and a manual provided by the manufacturer. In particular, each of equipment should be installed and assembled under the direction of a supervisor dispatched by the manufacturer.

An equipment base founded with concrete shall be fixed with an anchor bolt before laying concrete. A conduit shall be buried before laying concrete and shall be given enough time to cure the concreted surface.

When installing equipment, the chief engineer shall examine the appearance of a concrete foundation including cracks, holes, or foreign substances, and check the location and figure of foundation, its bolt holes, or buried metals. After he confirms that equipment has been constructed in accordance with the drawing, it can be installed.

When attaching a panel to a wall, a foundation bolt shall be fixed onto the wall first, and then stuck to a panel.

Equipment shall be welded to structure or fixed with a bolt having enough strength to support the equipment's weight.

Before installing equipment, the constructor shall clean dust or foreign substance happened
during storage or transportation. And check damage, oil leaking, or other problems.

When transporting or installing equipment, the constructor shall pay an extra attention not to break equipment, meters, or relays or change the fixed value.

It is not allowed to use an iron hook or a beam when transporting weigh cargo.

After being fixed hard with a foundation bolt, equipment shall be operated or adjusted. And then checked by a supervisor.

Adjustment of important equipment shall be done under the direction of a supervisor.

It is when transporting equipment, the constructor shall pack completely and then safely transport to its final destination.

When unpacking at an installation spot, the constructor shall unwrap the package using appropriate hand tools and be cautious not to give any shock to the equipment.

The wrapping, transporting or unwrapping of main equipment shall be done under the direction of a supervisor. If damage is done or a malfunction happens, the constructor shall notify the manufacturer instantly and repair.

When lifting equipment for adjusting location, the constructor shall not use an iron hook or a beam except for transportation hooks.

Each of equipment shall be balanced on a base channel. Then it shall be correctly arranged and fixed without distortion and strongly. The constructor shall examine the drawing thoroughly not to misconnect a bus bar or an electrical wire and make the appearance beautiful and well-ordered.

The equipment requiring assemblage in the field shall be assembled and installed after a drastic examination of its specification and other matters under the direction of a supervisor.

When assembling accessories connecting panels using a packing, the constructor shall paste adhesive on both sides of packing, and be cautious not to have excessive or lack fastening bolts.

When installing a foundation bolt on a wall or a floor, the constructor shall consult his supervisor in advance.

The location of equipment shall be in accordance with the drawing. When a change in the location for a cable Hole (Slab Opening) or others, the constructor shall consult a supervisor.

After installing equipment, the constructor shall check ground terminals and connect them. He shall connect more than one system ground network per case.

Any mechanical operation shall not be weighted.

Local operation and control panels shall be floored on a foundation concrete thick more than
5. Electronical Specification

50\text{mm}, Anchor bolts and nuts shall be of stainless steel.

The constructor shall measure an isolation resistance or internal voltage in installing or assembling equipment and proceed to the next stage.

The constructor shall execute all preparation works, pre-tests, or auxiliary functions for or during each experiment and trial tests. A disqualified item, if any, shall be corrected and rechecked.

5.1.2 Electricity and Control Cable Construction

5.1.2.1 Scope

This specification shall be applied to electricity and control cable construction if electrical, measurement and control works.

5.1.2.2 Reference Standards

The relating standard shall be of IEC 60183, 60227, 60502, 60885.

5.1.2.3 Description of the Works

A cable shall be installed within trays, pits, conduit tubes, or ducts otherwise.

The constructor shall not connect a cable in the middle without supervisor's approval and use an approved method in treating a cable's terminal.

A cable shall be laid level without damage, twist, or bending in installing. The damaged cable shall, if any, be checked or tested under the direction of a supervisor and then used.

All cables with a shielding layer shall be correctly grounded in a box or a panel where cable termination is treated.

A cable shall be stored in temperature and within periods that the manufacturer prescribes.

Cables adjacent to other facilities or installed in a place mechanically or physically damageable shall be protected with an approval of a supervisor.

All cable shall be strongly upheld at least in 1 m from its terminal. The cable terminal shall not be weighted down vertically. Cable glands used for this aim shall be approved by a supervisor.

Lubricant used for cable installation shall be recommended by the cable manufacturer and not chemically harm cable's insulation cover.
The maximum tension and speed when pulling a cable shall not exceed values that the cable manufacturer recommends.

Cable terminals shall be moisture-proof when installed outside or in a damp place.

The constructor shall install an appropriate size of a pulley at a tray bending part and pull a cable.

To protect against welding, a cable shall be temporarily covered.

The installation of a cable in a tray shall not be directly crossed with other cables except for incoming or drawing out parts.

When a cable tray proceeds in a vertical direction, the constructor shall fix the cable at every 1 m or less than it.

When installed horizontally, cables shall be bound maximum at every 2 m.

The constructor shall compare the laid cable with the drawing and prohibit people or heavy goods from stepping on the table.

Cable connected to an equipment form a tray or a duct shall be installed inside a conduit.

Each cable shall use a ring-shaped compression terminal attached with a numbered identification tag at its both tips.

An identification tag shall be attached near a terminal block or a lug not to project outside an exterior box.

A main circuit conductor shall be colored in accordance with regulations at either the terminal or part of box.

About AC polarity in the machine or tool, distributing board terminal, test terminal and inner panel should be installed to face to the supervision controller side, the main circuit should be installed to face to the controller of circuit breaker.

In case of using many cables on the one phase, same brand cable should be spread out evenly to prevent discrepancy of electric current.

The minimum size of a cable is 1.5㎟ for F-CVV, 2.5㎟ for F-CVVS, and more than 2.5㎟ for F-CV.

In case of cutting high voltage cable, it should be covered with plastic cap and winded up with magnetism bonding tape to prevent dampness except in case of performing connection or terminal treatment immediately.

In case of spreading cable in the access floor, it should be spread by tray, in case of spreading electric cable and measuring control cable, they should be separated.
5. Electronical Specification

Ring-shaped compression terminal should be attached on the termination of wire and cable, but compression terminal could be omitted in case lug or clamp is installed.

Terminal materials of high voltage cable is noninflammable plastic that has trait of insulation, anti-damage from sea wind, anti-ozone, anti-arc, anti-tracking, heat-resistant and cold-resistant, and it should be shrunk by itself so there is no space after installation.

Connector and terminal for connection materials should be have a trait of conductive disposition and mechanical intensity, and should be compressed by the compression tool.

A catalog of treating materials or a construction manual shall be submitted to a supervisor when treating a cable terminal with a high voltage cable head or a straight cable connector.

5.1.3 Cable Tray Construction Works

5.1.3.1 Scope
This specification shall be applied to cable tray construction works if electrical, measurement and control works.

5.1.3.2 Reference Standards
Refer to NEMA Standard VE 1 for definitions of cable tray terminology used in this section.

Components and installation shall comply with NFPA 70 “National Electrical Code.”

5.1.3.3 Materials (Not Applicable)
A cable tray should be constructed by a plan, and should be have an approval by a supervisor in case needs to be changed to keep away from the pipe and the other equipment.

A tray supporter should be installed in a turning point and each supporter should not be separated over 2 meters in the other case.

It needs to be finished supporter arrangement of cable, an external damage protection and treatment for external part to prevent mechanical damage for cable.

A cable tray should be made of steel over 2.5 millimeter thickness.

A tray should be cut with a saw or similar method and should not be cut with acetylene torch or similar method.

A welding an iron frame supporter to fix a tray is permitted, but a welding is not permitted for
a tray.

Joint plate is used for connection a cable tray each other, a tray should be apart 3-5 millimeter each other and attached ground bonding jumper to consider expansion and contraction by heat.

Cable should be connected to body of a cable tray completely using compressing terminal.

In case a tray goes through the wall, box connector should be attached at both side of wall and install a tray.

End plate should be attached at end of a tray.

In case of installation of tray or spreading cable, avoid working on the tray.

A tray is fixed to support angle with side rail clamp.

A cable tray should be installed apart from ground over specific height to avoid passing trouble.

All tray supporters should be have a safety to prevent any trouble in case added over 25% weight of dead load and spreaded cable.

Before inserting cable, all trays should be cleaned and removed sharp part to prevent the damage of cable insulation covering.

Cover is needed on the tray that installed in the open place.

A tray should not be attached to the ground or wall directly, it should be attached with channel or something like that.

In case a power cable and measuring control cable are spread at once in the same cable tray, it should be installed separator to prevent the interference by electromagnetic induction.

Cable for electric power or cable for controller that spreaded in the cable tray should be used fire retardancy cable or finished with flame retardant to prevent fire diffusion.

5.1.4 Outdoor cable construction works

5.1.4.1 Scope

This specification is applied to underground cable construction works of electric and measuring controller construction in the premises.

Required Paper

Product Data
Materials testing result paper
Construction Detail Drawing
Pipe route

Water-proofing equipment of pipeline coming from indoor to outdoor.

Documents

A blueprint of underground pipeline location.

Cable and Connection

Cable used for outdoor construction should be appropriate for standards and facility.
Avoid extension of cable as possible.

Carriage, Keeping, Handling

Underground pipeline materials should be avoided damage of cable cover and impact when it carried.

Environmental Demand

In the dampening place, install proper equipment.

Cooperate with Other Construction

It needs discussion with other construction manager to avoid duplication of reclaimed facility when install pipeline or cable.

5.1.4.2 Reference Standards

Parts and materials for underground cable construction should be qualified standard or better quality.

Rigid Vinyl Wireway.

Waving-shape Rigid Polyethylene Wireway.

Manhole and Manhole Cover.

5.1.4.3 Materials

Quality Control of Materials

Test
Skip test when quality guarantee mark are displayed
In case these items are not, these items should be have public testing by rule.
Rigid vinyl wireway : testing method and contents should be followed standards, testing should be done each sort of wireway and each standard.
Waving-shape rigid polyethylene wireway : testing method and contents should be followed standards, testing should be done each sort of wireway and each standard.

Underground Service Pipeline
Use waving-shape rigid polyethylene wireway for underground service pipeline.
Follow the plan for the size of pipeline.

Inspection
Materials should be inspected by supervisor before carrying in a job site.
Inspect the standard and structure with eye test, and the efficiency with testing report.

5.1.4.4 Construction
Criteria
Installing Method for Underground Wire Route
- Use cable for underground electric conduit, and construct by draw-in conduit system, covered conduit, or direct burying system.
- In case construct underground electric conduit by draw-in conduit system or covered conduit, use conduit or covered cable standing voltage of heavy things and preventing drain water.
- When place the cable in place carrying chemicals that melt a cable cover or an insulating materials, it should be laid with caution and it should be prevented chemicals from ground or it should be took measures before placing.
- It needs water-proofing in case it should be connected at curved place like a standing statue.
- Connecting part a wireway and manhole needs water-proof finish.
- Do the grounding construction to the steel for connection box that made of steel and inserted conduit, covered cable, underground cable and cable cover.
5. Electronical Specification

- Warning tape should be placed on the wire and the top of wire in order to represent placed wireway, it should be placed under 300 millimeter the ground.

- In the vacant pipeline, there should be packed a covering steel wire over 1.2 millimeters.

Installing Manhole

- A standard of manhole should be followed a design drawing, but in case of inconsistence for drawing from manhole and bending, it can be changed the size of manhole by supervisors order.

- Manhole should be solid to stand voltage of vehicle and heavy things and not easy to soak into manhole.

- Interior of manhole should be finished water-proof, easy drain and structured to remove puddle.

- Construct manhole cover not to be opened easily except constructor. Connecting part a wireway and manhole needs water-proof finish.

- Changing location of manhole should be approved by supervisor before construction.

- All steels that installed in manhole should be finished a corrosion inhibitor or use material not to be corrode, anchor installed on the manhole wall should be placed on the waterproof layer or installed with proper backup to prevent water.

Caution about Manhole

Approaching and crossing between underground wire and underground weak current wire

Between underground weak current wire and low-high voltage underground wire, its need to be apart each other over 30 centimeters, between underground weak current wire and very high voltage underground wire, its need to be apart each other over 60 centimeters.

In case of under 30 centimeters distance, it should be followed standard.

Digging and Back Filling

In case of placing cable to the underground directly, fill with fine soil to prevent cable cover damage by overhanging things, and fill back with original soil

Construction and Grounding of Underground Cable

- When installing cable in the manhole, clean inside before drawing in and draw in carefully to protect cable.

- Needs space near draw in gate and draw out gate of cable in manhole and handhole.
• Finish water-proof to prevent watering inside at draw in gate and draw out gate of cable.

• Avoid connection of underground wire, when connect underground wire each other, do not increase electric resistance, do not decrease power over 20%.

• Select insulation wire should have effect and treat not to be electrical erosion.

• When approaching or crossing between low-high voltage underground wire and underground weak current wire or underground optical fiber cable under 30 centimeters, and between very high voltage underground wire and underground weak current wire or underground optical fiber cable under 60 centimeters, install fire-resistant wall between underground wire and underground weak current wire or underground optical fiber cable, insert underground wire into fire-resistant pipe to do not contact directly with underground weak current wire or underground optical fiber cable.

• Metal goods of protector which installed underground wire, connector made of metal and metal for cable cover should be put to earth.

• Underground wire route should be installed separating from underground weak current wire not to generate communicating trouble by a leakage current or conduction.

• Install underground wire exposed on the ground as follows
  Install cable not to give inconveniences for transportation.

  In case installing cable in a place which might be accessed easily to people or damaged, put the cable in a metal pipe, gas pipe, or plastic pipe and the protection range should be at least two meters from the ground and twenty centimeters under the ground.

Installing Pipe for Cable Wiring

• Tilt to one end when installing the pipe and let the water drained. The pipe coming into indoor should be tilted toward the outdoor. Inclination should be at least one thousandth and in case it is hard to tilt, install a manhole and handhole in order for the water drainage.

• To connect the pipes, use compound or leak-prevention tape in order to stop water infiltration.

• In case connecting metal cable pipes, use a connector appropriate for cable pipes. When screwing on the pipe, make sure not to decrease the total pipe intensity and consider how to prevent screw corrosion.

• On the weak ground where there is possibility to change location of pipe install,
flexible underground pipes should be installed and the enough margin of the end of the cable should be taken in case of transformation.

Quality Control

Checking Construction

- Complete underground wire route construction and get supervisor's approval after inspection.
- Complete placing conduit and get supervisor's approval and construct back filling.
- Place the warning tape and get supervisor's approval and construct back filling.

5.1.5 Interior Wiring Works

5.1.5.1 Scope

This specification shall be applied to the interior wiring work if electrical, measurement and control works.

Relevant Specifications

Grounding works shall be in accordance with this section and others with the specifications of grounding facility works.

Documents for Submission;

Equipment Materials
Material Test Records
Shop Drawing
Interior Wiring Diagram
Other Drawings
Documents of Completion Verification
Construction Drawing of Interior Wiring

Transport, Storage, and Handling

When transporting into the construction site, the wiring equipment and its cover shall neither be damaged nor shocked.

Environmental Requirements

The wiring equipment installed in damp or wet places shall be water-proof and installed in a
fire-proofing place

Cooperation with Other Works

Wiring shall not obstruct other construction works executed simultaneously, and check their range in advance and consult a supervisor concerned.

5.1.5.2 Reference Standards

The relating standard shall be of IEC 60364.

5.1.5.3 Materials

Steel Pipe Constructions

Steel Pipe and Its Accessories

- The constructor shall use zinc-coated rigid steel conduits hot-dipped galvanized steel (more than 22C) in accordance with the regulations otherwise other remarks. However, HI-PVC conduits (more than 16C) shall be used for building electricity.

- Accessories of steel pipes shall use sizes of zinc-coated rigid steel conduits in accordance with the regulations.

- Steel pipe conduits shall be of steel, brass, or bronze and manufactured rigidly.

- The pipe thickness shall be more than 1.2mm when buried underground, and more than 1.0mm for the rests. However, it shall be more than 0.5mm when exposed to a dry place, as for a seamless pipe less than 4 m long. Its thickness shall be in accordance with the drawing.

- The inside and tip of pipes shall be smooth so that the conduits' cover shall not be damaged.

PVC Pipes Constructions

PVC Pipes and Parts

- PVC pipes, boxes, and parts should be appropriate for the standards.

- PVC pipes, boxes, and parts (except for dust explosion-proof flexible fitting) should be made with PVC except the boxes installed in the concrete and big pool boxes.

- The thickness of the pipes should be based on the blueprint.
5. Electronical Specification

Metal Flexible Cable Pipe Construction

Metal flexible cable pipes and parts should be based on the next standards

- Cable connecting the box and light on the ceiling slab in case of double ceiling.
  
  Conduit: the first type metal flexible cable pipes, non-waterproofed, 16 millimeters
  
  Coupling, connector, insulation bushing: the first type metal flexible cable pipe parts.

- Connecting cable at the end of motor and cable pipes installed machinery room and
  ventilating room.
  
  Cable: the second type water-proofed metal flexible cable pipes, or high-tensile
coflex flexible cable pipes.
  
  Coupling, connector, insulation bushing: the second type metal flexible cable parts.

- The thickness of the pipes should be based on the blueprint.

Box and Cover

Metal Box and Cover

- Cable metal box and cover should be suitable for the standards.

- The sizes of metal box and cover are based on the blueprint.

Rigid Vinyl Box and Cover

- Rigid vinyl box and cover should be suitable for the standards.

- The sizes of rigid vinyl box and cover are based on the blueprint.

Wiring Construction

General Quality

- Cable for wiring construction should not be bare wire.

- Insulation cable and cap adaptor should be suitable for the facility.

- Cable for indoor wiring should be low voltage indoor wiring according to standards.

- Cable standard in the blueprint is the least limit needed for the construction, so cable under the standards should not be used. The types of cables should follow the standards.

Wiring and Cable

- Cable materials and parts used for wiring construction should be suitable for the
standards or better than them.

Approved Cable

- Wire and cable should appropriate for the standards.
- Cable with metal reinforcer for insulation should be suitable for the standards.

Parts

- Wire connector for the indoor wiring.
  This is a wire connector used when dividing wire or sending lead wire and it should be suitable for the standards.
- Cable tie
  A cable tie is used when fastening cable in cable tray and duct according to feeders and it should be appropriate for the standards.
- Terminal block
  It is used in a controller, control board, and switch board for wire connection, division, and hookup and it should be suitable for standards.
- Insulating Vinyl Adhesive Tape
  Insulating materials used at the connector of cable and wire and they should be appropriate for the standards.
- Insulating Vinyl Tube
  It is used when it is impossible to differentiate the colors of cable and wire and they should be appropriate for the standards.
- Voltage Terminal for Copper Wire
  It is used in order to connect broken wires in power machine and wiring between machines.
- Voltage Sleeve for Copper Wire
  It is used to connect wires used in wire for machines and indoor wiring and it should be suitable for standards.

Management of Material Quality

Test

- Skip the test if the materials are appropriate for the standards.
5. Electronical Specification

- If the materials are not approved by authorizers, conduct the test.

**Inspection**

- Before bringing materials in, get construction supervisor's inspection.
- Inspection consists of bare-eye inspection about size and structure of the materials and test reports about performance.

**5.1.5.4 Construction**

**Metal Cable Pipe Construction**

**Cable**

- There should not be a connecting point on the cable in the metal cable pipes.
- In an alternating current circuit, put all of the cable of one circuit in the same pipes.

**Conduit**

- When there is a possibility of corrosion at the metal cable pipe and its parts because of screwing or peeling away of paints, protect them applying corrosion-resistant paint.
- In the metal pipe, keep moisture and dust away from it and clean it before putting the cable in.
- In the empty pipes, put vinyl coating steel wire which is more than 1.2mm.

**Connection and Support of Pipes and Parts**

- Connect between metal pipes and metal pipes and box perfectly and firmly according to the next standards.
  
  When connecting between metal pipes, use the same couplings and tighten firmly.
  
  When connecting a metal pipe and a box or similar things, use two lock nuts and tighten both sides of the connection of the box or cabinet.

- Metal pipes, boxes, and other stuff used in metal cable piping should be supported with a proper prop.

**Curves of the pipe**

- When bending the metal pipes, make sure cross section of the pipes should not be distorted and radius of the inside should be more than six times the pipe's diameter.
• Do not make more than three right angle bending spots in the metal pipes between outlet boxes and between structures with inlet of cable. If there are many bending spots or the pipes are more than 30 centimeters, install a full box.

• Do not hide universal elbow, T, cross at the construction structures.

Protection of cable at the end of conduit

Keep in mind the next points in order not to damage the coating of the cable in case of putting the cable in or exchanging it at the end of cable pipes

• Use bushing at the end of cable.

• Use an entrance cap at the top of outdoor vertical pipes.

• Use a terminal cap or an entrance cap at the end of outdoor horizontal pipes.

Points to consider in-concrete piping

• Pipes in concrete should be fixed with a reinforced rod and make them not move in case of concrete spreading.

• When installing cable pipes in concrete slab, outside diameter of the cable should be less than one third of slab thickness. The cable whose radius is more than 36mm basically should not be installed in the slab (except for the case the thickness of slab is more than three times outside radius of the cable). But if it is unavoidable, design the blueprint not to make any structural deficiency and get the supervisor's approval before the construction.

• The cable pipes should be installed in the middle of the top and the bottom of the reinforcing rod. Without permission, do not cut connecting line and the reinforcing rods or remove prop for the reinforcing rod. Removed connecting line or props should be restored immediately.

• When installing the cable pipes in parts of concrete structure, put them at an interval of 25mm.

• When arranging the cable pipes horizontally, arrange them at an interval of 30 mm. Make sure concrete should not be inserted in the connecting points of cable pipes and block the ends of the cable pipes with a plug in order to prevent dirt or rainwater from flowing in.

Grounding

• Do not insert wood or insulators to the pipe route from the ground wire leading to the end of metal cable pipes.

• If the box is painted with an insulator, peel it completely and attach locknut, bushing, or grounding devices to it. After attaching it, repaint with the insulator.
Quality Management

- Confirmation of the construction state

After finishing construction of metal pipes, check the construction state, sign, and submit the confirmation paper to get the supervisor's approval.

Get the supervisor's approval according to the following

- In case of cable pipes in concrete: Get an approval before spreading the concrete.
- In case of uncovered pipes: After piping construction.

- If the box is painted with an insulator, peel it completely and attach locknut, bushing, or grounding devices to it. After attaching it, repaint with the insulator.

PVC Pipes Construction

Cable

- Do not make a connecting point of cable in PVC pipes.
- In empty pipes, put a vinyl coating wire which is more than 1.2mm.

Piping

- Do not install PVC pipes in a place that there is voltage, or severe mechanical shock.
- Make the end of PVC smooth in order to prevent damage to the cable coating.
- Install pipes and boxes according to the following.

  When installing PVC uncovered, install at an interval of 25 to 30 meters in order to prevent disasters coming from temperature change.

  Do not decrease building strength by intensively piping in the concrete, do not tie more than three pipes to the same direction, and put the pipes at an interval of 25 mm.

  Install the pipes in concrete along the reinforcing rod, in the wall, install vertically, and try to avoid horizontal piping.

Connection and Support of Pipes and Parts

- Connect between PVC pipes or PVC pipes and other parts and prop firmly on the building.
- When supporting PVC pipes with saddle, the distance between supporting points should be less than 1.5 meters, and the supporting point should be located in a place close from the connecting points between the pipes and the box and between
pipes-for example 0.3 meters.

- When connecting the PVC pipes each other or the pipes and the box, the depth of insertion should be more than 1.2 times outer diameter of the pipe (in case of using adhesives, 0.8 times) and connect firmly.

- When putting PVC flexible pipes or CD pipes in a box or full box, make sure the water do not soak into the box or full box.

Protection of cable at the bottom of the pipes

Protection of cable at the bottom of the pipes follows the standards of metal cable pipes construction.

Points to consider when piping in concrete

These follow the standards of metal cable pipes.

Uncovered Pipes

Fasten uncovered cable pipes each within 1.5 meter. Fasten cable pipes at less than 30 centimeters at the connecting point between the cable and the box.

Grounding

Follow the standards of metal cable piping construction when connecting PVC pipes and metal full box.

Quality Management

Quality management is based on the standards of metal cable piping construction.

Metal Flexible Cable Piping Construction

Cable

Do not make connecting point in metal flexible cable pipes.

Piping

- Do not install metal flexible pipes at the place where there might be external damage.

- The first type flexible cable pipes can be used at a dry place which is uncovered or closed with checking possible (in case indoor voltage is more than 400V, use them when flexibility is needed).

- Make the end of metal cable pipes and parts smooth in order to prevent the damage to the cable coating.
5. Electronical Specification

- When bending the second type of metal flexible cable pipes, follow the next points.

  When it is easy to install and to remove the pipes in a place that is uncovered or closed with checking possible, the radius of curvature should be more than three times inside diameter of the flexible cable pipes.

  When it is impossible to install or remove the pipes in a place that is uncovered or closed with checking possible, the radius of curvature should be more than 6 times the second type metal flexible cable pipes.

- When bending the first type metal flexible pipes, the radius of curvature should be more than 6 times inside diameter of the pipes.

- Do not use sharpbend.

Installation of metal flexible cable pipes

- Connect metal flexible cable pipes and their parts perfectly in a mechanical and electrical way and support them firmly on the structure.

- Connect metal flexible cable pipes each other with coupling.

- Connect metal flexible pipes and box or cabinet with a connector.

- When connecting metal flexible pipes with distributing wires or metal mold distributing wire, use a proper coupling or connector and connect them perfectly with mechanical and electrical perfection.

Protection of cable at the bottom of the pipes

Protection of cable at the bottom of the pipes follows the standards of metal cable piping construction.

Grounding

Grounding of metal flexible cable pipes and their parts follow the standards of metal cable piping construction.

Quality Management

- Check construction state.

  The constructor should check construction state after finishing cable piping construction, and get the supervisor's approval.

Wiring Construction

Preparation
When putting cable or wire in cable pipes or cable tray, remove moisture and dirt completely in the pipes and tray.

Wiring

- In case of standing main line, install U channel in the full box and cover with rubber packing and fix with clamp.
- Treatment of terminal of electricity main line

Use copper wire voltage terminal and fix the terminal of electricity main line.

- Use of lubricant when putting the wire in

When using lubricant for the cable, do not harm to cable cease, use grease that doesn't stick to the pipes or white vaseline that doesn't include metal substance.

- Connection of cable

When connecting cable, make sure electric resistance, insulation resistance, and decline of tensile strength do not happen.

When removing insulator for the cable connection, use wire stripper to prevent damage to the wire.

Connection of cable should be done in a place checking is easy such as junction box or inside devices and do not connect in a closed place with checking impossible, in cable pipes, floor ducts, and other ducts without a lid.

The way to connect follows related standards and use insulating tape at the connecting points except when using a connector which has an insulating effect like an insulator.

- Connection between cable and device terminal

When connecting the cable and the device terminal, follow the next points.

When fixing the cable with screws, use double nuts, spring washers or screw laxity prevention devices at a place where there is a possibility of loosening the screws because of vibration.

Do not more than two cables at the terminal that can connect one cable.

Cable Wiring

- Points other than those in this specification should follow related standards.
- Installing methods

Do not install cable at a place where there is a possibility of voltage and severe
5. Electronical Specification

mechanical shock, but it is okay when the cable is in metal pipes, gas pipes or PVC pipes.

Do not put the cable in the floor, wall, or pillar directly, but it's ok when the cable is put in appropriate metal pipes, gas pipes, or PVC pipes.

When installing several one big wire cables, arrange them reasonably and make the length and the distance of cable regularly.

When wiring cable in a cable tray, make sure the wires not to be entangled.

- Supporting of cable

When supporting the cable with cleat, saddle, or staple, fix them firmly not to damage the cable.

When wiring the cable in the cable tray, fasten the cable with a tie within every 2 meters.

In case of closed wiring, you don't have to support the cable only when installing the cable with tension not applied.

When fixing cable in a moist place, make sure cable not to fall out from the corrosion of structure fastened with cable fixer, nut, bolt, screw and washer.

- Bending of cable

When bending cable, make sure not to damage the coating, the radius of curvature of the bending should be more than 6 times outer radius of cable (in case of one wire, 8 times).

- Connection of cable

When connecting cable, make sure not to damage the conductor and coating following the next points.

  - When connecting cable each other, do it in the cabinet, outlet box, or connector or do not the connecting points uncovered using proper connecting box.
  
  - When connecting the cable with device terminal, do it in the cabinet or outlet box.
  
  - Make sure the connecting box with the terminal to be checked.

  - When connecting cables with big cross section each other with difficulty in following the related standards, use insulating tape with self-adhesive property or protect it by putting an insulating plastic tube in.

  - When connecting cable and insulating wire, bend the end of outdoor cable downward and make sure the rain not to soak in.
Before connecting the cable, remove dirt completely. When connecting the copper wire and aluminum, use voltage slab in order to prevent corrosion and connect completely.

When connecting polyethylene insulating cable, do not install in rainy day or wet place to make sure to prevent insulating destruction by water tree that happens from water penetration. Also make sure sweat or rain not to penetrate in.

When connecting low voltage cable, use copper wire voltage sleeve joint and thermosetting contraction tube, resin injection kit or self-contraction tube.

When laying cable, pull less than permitted tension.

• Protection from something with high temperature

Install low voltage indoor wiring more than 15 centimeters away from a chimney, or heater. But if it is impossible, insulate them with rock wool or glass fiber.

Quality management

• Checking construction state.

The constructor should get the supervisor’s approval after completing wiring.

5.1.6 Lighting and Receptacle Facility Construction

5.1.6.1 Scope

This specification is applied for the lighting and receptacle facility construction of lighting equipment, distribution board and wiring.

Relevant Specifications

Matters that related to the lighting and electric heat facility construction should be followed as follows except presented in this specification.

Piping and Wiring

Follow the specification of interior wiring works.

Grounding

Follow the specification of grounding facility works.

Required Paper

Data of products
5. Electronical Specification

- Figure diagram
- Circuit diagram
- Material catalogue and production specification

Test Report

Manufacturer's test report for lamp and safety

Shop Drawing

- An arrangement plan of lighting equipment (mark standing method, piping and wiring)
- An installation diagram of lighting equipment (height and method)
- The rest drawings

Completion Document

An explanation for lighting equipment maintenance (repair and exchange)

Production Diagram and Sample

In case produced according to drawing, submit a production diagram and sample marked structure and installation method, and get supervisor's approval and produce.

Transportation, Storage, and Handling

When coming in to working spot an incandescent electric lamp, a fluorescent lamp, high brightness discharge lamp and etc., avoid damage and impact

Environmental Request

Lamps and electric machinery used at damping spot should be installed proper spot.

Cooperate with Other Works

When construct lighting and electric heat facility, check the construction range of other works. Install safely for building construction, make it easy to attachment, disassembly and maintenance.

5.1.6.2 Reference Standards

A related standard should be followed IEC 60083, 60598, 60669, 60884, 60906, 60947.
5.1.6.3 Materials

A related standard should be followed IEC 60083, 60598, 60669, 60884, 60906, 60947.

General for Lamp

The lamp should be assembled by screw or welding not by soldering. When using screw, tighten fast not to lose or use a nut or anti-loose tool.

Lamp using an incandescent electric that attached a reflection shade, a globe, a diffuser and a socket, should not be made by the inflammables, a melten thing and a transformed thing like PVC.

Lamp should not be made by things easy to be melted, transformed and changed color. Especially, these things should not be used in the places that conveyed heat from a heating unit, connected with bulb or ballast stabilizer, sparked when it explode. But these things can be used in the places that are safe and airy for decorating cover.

Wire and electrification part of lamp should be concealed, the wire should not be seen and hinder when it lighting.

The wire used in lighting equipment should be stand maximum temperature, skin temperature of a heating unit (include bulb, socket, ballast stabilizer, etc.) connected with wire that allowed in normal condition and abnormal condition in the lamp. Connection between lamp and external wire should be operated in terminal installed in lamp.

The wire in the lamp should be stand over 100°C in normal condition, in case of any temperature rising generated in lamp it should not be changed trait and damaged an insulator.

Minimize wire connection in the lamp, all connection should be operated at 300V level terminal block that can go through loading electric current safely and be insulating cover. Wire connection in the spot that cannot use terminal block, should be connected by sleeve or soldering and insulate inserting tube insulator that not peeled and not changed by internal heating and not lowered trait and has equivalent thermal resistance with using wire.

Coating

Steel part of distribution board and lighting equipment should be coated not to be rusted.

Coat as standard.

Covering color of distribution board should be matched with the surrounding.

Reflective surface color of lighting equipment should be white and external surface color should be followed constructor’s standard when there is no drawing and instruction of supervisor. Finishing of lamp should not be peeled and not be changed color by generating
5. Electronical Specification

heat from inside of lamp or surrounding condition, and not be corroded lamp, and colored properly with circumstance.

**Incandescent Lamp Lighting Equipment**

**General Structure**

- The lamp should be used proper good for standard or better quality.
- The machinery should be composed good materials, has durability and attached structure firmly.
- In case there is worrying about burning or corrosion of steel part of lamp, finish rust-resisting treatment.
- The lamp should be exchanged the bulb easily during light.
- Under the normal condition, the bulb should not be apart from equipment and broken by oscillation or impact.

**Connecting Part**

- Needs good and sufficient thickness for connection of steel part, and need to be screwed or coated or welded instead of soldering for connecting part.
- Screw of machinery part should be tighten completely or use a nut or not loosed one.
- Do not connect with screw for connection part of aluminum.

**Finish**

- Finish and color of lamp should be followed drawing or instruction of supervisor.
- Coating of steel part should be finished durably and no defect, and colored the same color of rust-resist painting and basis painting except a part covered with ceramic.

**Shade and Globe**

- Connection part between shade or globe and holder should be suitable for standards.
- Glass should be no foam, defect, modification should not be seen filament of bulb using good transmission and diffusible milky-white colored glass.
- Steel reflecting shade should be finished no rust, defect and modification, and good reflexivity and durability.

**Incandescent Lamp**

Incandescent lamp should be suitable for standards or better one.
Base and Socket of Bulb

Base and socket of bulb should be suitable for standards or better one.

Wiring in the machinery

- In case worried about wire damage by a high temperature, protect wire winding insulating tube or asbestos, or use heat-resistant wire.
- Do not make connection point to the wire of machinery. But can make connection point in checkable place like a chandelier.

Damp-proofing Machinery

- Machinery used in damping place should be damp-proofing type equipped screw globe or rubber packing.
- Steel part of the lamp should be used brass, and iron part should be finished with zinc galvanizing or rust-resistance.

Explosion-proof Machinery

- Explosion-proof machinery should be used in the place that exists explosion danger.
- Materials of the lamp should not be penetrated by explosive gas, machinery should be attached cover to protect lamp and guide.

Outdoor Lamp

- Outdoor lamp should not be allowed rain drop or dust.
- Use bulb for outdoor at place that exposed by rain, and use waterproofing holder or socket.

The Rest Lighting Machinery

Outdoor machinery should be used airtight type to prevent stain and fire of bulb or reflecting shade, and used open type reflecting shade for indoor machinery.

Materials QC

- Test

Skip the test if the materials are appropriate for the standards.

If the materials are not approved by authorizers, conduct the test.

- Inspection for incoming materials

Materials should be inspected by supervisor before carrying in a job site.
Inspect with eye test, and the efficiency with testing report.

**Fluorescent Lamp Lighting Facility**

**General Structure**

- The lamp should be used proper goods for standard or better quality.
- The machinery should be composed good materials, has durability and attached structure firmly.
- Electric charging part should not be got an electric shock when it using or exchange lamp and glow starter except lamp and socket, structure to easy exchange lamp and glow starter in using.
- Under the normal condition, the lamp should not be apart from equipment and not be broken by oscillation or impact.
- There is no trouble in each part or there is no bad influence for trait and life of lamp, because of temperature rising during the lighting.
- Globe and lighting cover should be structured no trouble by insect or dust entered into machinery.
- Accessories (e.g. ballast stabilizer, power factor improvement condenser, discharge condenser, starter, base and terminal block) should be installed in lamp, and these accessories should be apart each other concerning heat-interference or easy wiring, and installed firmly.
- Follow the specification and drawing for sort, quality and detail installing method of louver. Choose a suitable louver for installing height, installing circumstance and light distribution of the lamp.
- Steel plate used in the lamp should be regulated one or better one, and should be over 0.7 millimeter.
- Power connecting terminal block and grounding terminal should be attached in the lamp.

**Ballast Stabilizer**

The electric ballast stabilizer for fluorescent lamp should be used proper goods for standard or better quality.

**Lamp**

- The fluorescent lamp should be used proper goods for standard or better quality.
- A light source should be colored daylight blue or white in case not mentioned by
Power Factor Improvement Condenser

- Install power factor improvement condenser in the lamp. But, except in case of sustaining power factor over 90% added ballast stabilizer inside circuit like an electric ballast stabilizer.
- The condenser should be used proper goods for standard or better quality.
- Condenser should be allowed temperature over 85°C and 300V.

Radio Interference Prevention Condenser

- Noise-resistant condenser should be installed in the lamp to prevent a radio interference of the other electronic machine by fluorescent lamp. (in case of glow starter type fluorescent lamp) But, except in case of installing an anti-electromagnetic wave circuit in ballast stabilizer like an electric ballast stabilizer.
- The condenser should be used proper goods for standard or better quality.

Glow Starter

The glow starter for fluorescent lamp should be used proper goods for standard or better quality.

Socket

- The fluorescent lamp socket and glow starter socket should be used proper good for standard or better quality.
- Use insulting type socket for fluorescent lamp.

Wiring

- Use protector bushing or proper protecting tool in the place that wire goes through the metal, not to damage cover of wire.
- Wire used in machinery should have heat-resisting property according to using temperature of part that concerned touching wire.
- The wire in the lamp should not be contact to ballast stabilizer directly. Wire should be fastened body of lamp with bandage orderly to prevent drooping.

Assembling

- The wire in the lamp should not be contact to ballast stabilizer directly, wire should be fastened with bandage orderly.
- Ballast stabilizer of fluorescent lamp should be installed at every fluorescent lamp.
5. Electronical Specification

Materials Q.

- **Test**

Skip the test if the materials are appropriate for the standards.

If the materials are not approved by authorizers, conduct the test.

- **Inspection for incoming materials**

Materials should be inspected by supervisor before carrying in a job site.

Inspect with eye test, and the efficiency with testing report.

**High Brightness Discharge Lamp Facility**

- **General**

  - Follow the specification and drawing for standard, lighting method, using condition, external shape of the lamp and installing method of the lamp.

  - Produce the open type or airtight type for the lamp, and all materials should be used steel and heat-resistant glass certainly. The lamp should be safe for handling, easy to exchange bulb, easy to check inside, easy to clean, and emit the heating of inside sufficiently.

  - All materials for inside of lamp should be used not burning against change of internal circumstance.

  - Airtight part in the open type and airtight type of indoor lamp and outdoor lamp should not be intruded by dust, insect, water, especially, airtight type and reflecting shade of outdoor lamp should be structured airtight.

  - Steel reflecting shade should be suitable for standard.

  - When made reflecting shade with aluminum, stainless steel, extra reflecting glass it should has same quality with steel reflecting shade, and be used very diffusible material for reflecting surface.

  - The front side glass and globe of the lamp installed at front of the airtight type should have good transmitting rate, easy to clean, easy to exchange, safe, no foam, defect on the glass and should be stand temperature changes following circumstance.

  - The lamp should have proper lighting angle following using condition, lighting proper direction, and have speed enough.

  - Steel part of machinery should be used corrosion proof material or finished heating and corroding prevention.
• There is no trouble in each part or there is no bad influence for trait and life of lamp, because of temperature rising during the lighting.

• Install the grounding terminal in the machinery or should be structured easy grounding.

• In case installed ballast stabilizer in machinery, should not affect to ballast stabilizer by temperature rising of machinery.

• The machinery should be made with good material, be safe, be durable, and be installed at lighting pole firmly.

• Under the normal condition, the lamp should not be apart from equipment and not be broken and not be loosen by oscillation or impact.

• Use protector bushing or proper protecting tool in the place that wire goes through the metal, not to damage cover of wire.

Metal halide Lamp and Accessories

• Attach the base not to separate during the use.

• Stay away charging part mutually or charging part from external box enough.

Socket

Use appropriate ceramic or PVC for the metal halide lamp socket.

Materials Q.C.

• Test

Skip the test if the materials are appropriate for the standards.

If the materials are not approved by authorizers, conduct the test.

• Inspection for incoming materials

Materials should be inspected by supervisor before carrying in a job site.

Inspect with eye test, and the efficiency with testing report for the standard, size, and structure.

Distribution Board and Wiring Equipment

Distribution Board External Box

• Distribution board should be used proper good for standard or better quality except particular one.

• Use 1.5 millimeter for internal box, 2.1 millimeter for external box.
5. Electronical Specification

- Use 2.0 millimeter stainless steel for the door of distribution board.
- Install grounding terminal to connect grounding wire in the external box.
- Produce the door to put distribution board wire diagram in.
- Attach the suitable tablet on the distribution board.

Machinery name: Decide after discussing with supervisor.

Tablet material: black letter piece on the clear acrylic board.

- Follow the instruction of supervisor for distribution board color.

Electric Conduction Part

- Use band shape bronze conductor for electric conduction part. (buss bar and branch conductor).
- Conducting rate of buss bar and branch conductor should be over 90%, current density should be followed standard about rated current of buss bar and branch conductor.

Circuit Breaker for Wiring

Wiring circuit breaker should be suitable for the standards or better than them.

Short Circuit Breaker

Short circuit breaker should be suitable for the standards or better than them.

Electric Switch

Electric switch should be suitable for the standards or better than them.

Terminal Board

Install proper terminal board for loading capacity to the lower end of distribution board.

Electrical Outlet

- Electrical outlet should be suitable for the standards or better than them.
- Use wall socket installed earth electrode.

Switch

Switch should be suitable for the standards or better than them.
5.1.6.4 Construction

Equipment Condition

Voltage and flickering of the lamp

- Rated voltage should be 230V except extra requirement.
- The lamp switch circuit for lighting should be followed drawing.

Arrangement of the lamp.

- Install the lamp after investigation of finishing method of ceiling, ceiling structure, installing method of the lamp, reinforcing method and finishing method of ceiling caused by installing the lamp, condition of incoming location of the lamp, installation or not of other facility in the incoming location of the lamp, maintenance after installation of the lamp, existence and nonexistence of heating unit around location of the lamp, arrangement method of other equipment and links between these things.
- Arrange the lamp after getting of supervisor's approval with preparation of the lamp arrangement plan and construction detail drawing.

Installation of the lamp

- Install the lamp so as to be easy maintenance like bulb replacement, replacement and withdrawal of the lamp body.
- Install the lamp to stand over three times load of the lamp weight, not to drop against oscillation or impact.
- Installation in the extra place

Damping place

Lighting facility installed in damping place should be installed not to intrude water in wiring way, socket and electric part.

Corrosive place

Install the lighting facility with suitable way in the corrosive place.

Glow Lamp Lighting Facility

Installation of the Lamp

- Install the machinery with proper method about weight of the machinery and installation place, and discuss with supervisor about detail.
- Apart a bulb from combustibles sufficiently, install the machinery opened the bottom at out of person's reach, and install safely.
5. Electronical Specification

- Install the wire reached lighting equipment from interior wire following the specification 5.0 interior wiring works.

- Switch box installed in incoming type lighting equipment should be installed at inspectable place.

Construction Method of Code Pendent

- In case of hanging something with code pendent, whole amount of weight should be under 3 kilograms.

- In case of using the rosette, attach the rosette horizontally make it vertically with code hole.

- In case construct code pendent with fixing equipment, connect code and interior wire by rosette attached bottom of ceiling or code holding insulator.

Q.C.

- Inspection of construction

Needs supervisor’s approval for the lamp installation.

Fluorescent Lamp Lighting Facility

Installation

- Install the machinery with proper method about weight of the machinery and installation place, and discuss with supervisor about detail.

- In case of installing the lamp with other facility (supply facility, speaker, sensing device, sprinkler head) in a line, the lamp should be consistent with size of sticking board, installation method, finish method after discussing with the other constructor.

- Needs discussion about material and structure for ceiling, if not agreed, follow supervisor’s instruction.

- In case of installing the lamp continuously, it should not be exposed the wire and connected with proper method and proper tools.

- The lamp should be installed by same method and installed with same level and installed in a line.

- Machinery should be installed so as not to crack at installing surface and nicely.

- In case of installing the machinery to steel, use a bolt or a screw or a hook bolt except installing on the tex holding bar.
Grounding

- Do the grounding construction to the steel part of the lamp and external box of ballast stabilizer for discharge lamp as follows.

In case of using high voltage for the cable between ballast stabilizer and lamp, and in case rated 2nd short circuit current of transformer for discharge lamp or operation current of circuit exceed 1A, do the grounding construction as follows 1st class.

In case of using low voltage for the cable between ballast stabilizer and lamp over 400V, and in case rated breaking short circuit current of transformer for discharge lamp or operation current of the cable between ballast stabilizer and lamp exceed 1A, do the grounding construction as follows extra 3rd class.

In the other case, do the grounding construction as follows 3rd class.

- Skip the grounding construction in case of coming under follows.

  Construction of the cable between ballast stabilizer and lamp with under 150V operating voltage in a dry place.

  Construction of the cable between ballast stabilizer and lamp with under 400V operating voltage in a dry place that have no access to people in case installing the outer box of the stabilizer or metal parts of the lighting not to connect with metal structure.

  Construction of the cable between ballast stabilizer and lamp with under 400V operating voltage or the second short circuit current of the transformer or action electric current with under 50mA in case putting the stabilizer in the outer box not to connect them with lighting electrically.

  Installing wood show window in a dry place or the outer box of the stabilizer and metal parts connecting with it not to contact with people easily.

- Pipes for the lighting are made of metal connect piping and the body of lighting device firmly (only for conductor) in order for grounding continuity and bond with ground wire if grounding continuity is impossible.

- In case of non-conducting substance such as PVC for piping, connect the grounding wire with the light and install grounding terminal in the light when grounding the light.

Quality Management

Quality management follows the standards of glow lamp lighting equipment.

Installing Discharge Lamp with High Brightness

Installation
5. Electronical Specification

- Install lamps appropriately according to their weight and place and other specifications follow discussion with the supervisor.
- Install the installing holder firmly with screws or bolts.
- Install outdoor lamps firmly and put the stabilizer and a switch in a box with fire resistance and install them indoor. Install them at the bottom of a pole or in a place that is fire and water resistant and easy to check.
- Install bracket and pendant along the wire preventing water penetration.
- Supporters installing a light projector should be made with metal in order to protect them from rain or wind.

Grounding

Grounding follows the standards of fluorescent light equipment.

Quality Management

Quality management follows the standards of incandescent electric lamp lighting equipment.

Distribution Board and Wiring

Installing the distribution board

- Install the distribution board in a place where operation of electricity circuit or a switch is easy, in an uncovered place, and in a safe place.
- Distribution board with uncovered electric charge should be installed in a place where unauthorized persons are not easy to access.
- Install the distribution board in a dry place.
- Installing height follows the blueprint. If it is not mentioned in a blueprint, from the floor to the top of the box is 1.8 meters.

Installing the distribution board

Install the distribution board in a proper way except when installing a cover knife switch that doesn't uncover charger all the time such as cutout switch and wiring.

Grounding metal frame of distribution board

Metal box and metal frame supporting it follow the standards grounding installing construction.
Installation of wiring equipment

- Follow drawing for installing height of wiring equipment, follow next point for not marked thing.

Installing height of switch should be 1.2 meters from ground to center of switch.

Installing height of the wall socket should be 0.3 meters from ground to center of the wall socket.

Install extra wall socket at proper height, and discuss with supervisor.

- The switch attached lamp directly should be located at center of equipment, or located at point not to move when it switching. The lamp should be installed not to hinder traffic and easy to control.

- The switch should be installed in the place easy to find by controller and do not install some equipment that hinder to control switch at front of switch.

- Make certain opening and shutting direction, being or not of obstacle, whether installation of wiring facility or switch is possible or not with checking final drawing before constructing wiring works for switch.

- All switches and other controller should be installed vertically against finishing surface of ground as a rule if not requested from drawing.

- All kind of switch should be safe when it operating and so as not to vibrate.

- Switch should be attached with over 2EA of box screw to box. (it is 1EA assembled in 1EA sticking frame for the connected).

- Switch and the wall socket installed by incoming should not be protrude than finishing surface. And plate should be attached to the switch with over 2EA bolt in order to close with finishing surface of structure.

- Separate switch from each other not to generate accident like an arc.

- Install the switch at opposite side of ground on the wireway.

- Install switch and wall socket to match structure finishing surface.

- The wall socket should not be hidden by furniture or machinery and located easy to insert the plug and located easy to find by user. There should be no facility may get damage by generating arc from plugging around the wall socket. There should be earth electrode that is structured not to plug with different voltage.

- Equipment of the same object and same power type installed in structure should be used same inserting method and used same sort of plug.
• Confirm installing location of the wall socket with checking the final drawing and finishing method of the structure, being or not the obstacle or dangerous object, sort and location of equipment that inserted in the wall socket before starting construction.

• Install one of the wall sockets per one box except extra case. (it is admitted one thing that has 2 hole or installed in one sticking frame continuously.)

• Install the wall socket so as not to move when insert or pull out the plug. All the machinery should not be used corrosive, shrinkable, flammable or melting materials.

Wire connection

• Cover of wire should be removed by striper so as not to reveal the charging part.

• About connection between the wall socket or switch and wire, wire should be inserted in the pin perfectly.

• Check the connecting status with pulling after inserting the wire into the pin.

Grounding

Do the grounding construction to the wall socket in accordance with 3rd class.

Q.C.

• Inspection

   Needs supervisor's approval for the distribution board installation.

5.1.7 Lightning Protection System

5.1.7.1 Scope

The present specifications shall be applied to the lightning protection system and the related grounding system for buildings or internal facilities.

Related Specifications

Wires shall be laid in accordance with ‘Indoor Wiring Work’, with the exception of the provisions stipulated in the present specifications.

Submission

Data

• External Draft

• Arrangement and Connection Plan
Working Plan

A working plan shall be made out and shall be approved by the superintendent.

5.1.7.2 Reference Standards

The relating standard shall be of NFPA 780.

5.1.7.3 Material

Generals

Lighting protection system shall be constituted by the lightning rod and the conducting wire and the horizontal conductor, and those components shall satisfy the related regulations.

Lightning Rod

The lightning rod shall be single-rod or shall have further performance.

The lightning rod shall endure wind load.

Its material shall be stainless steel, aluminum or copper in accordance with the specifications.

It shall be free from corrosion and damage even in the zone of corrosive gas or sea wind.

The material of lightning rods and its support shall be semi-permanent.

The stainless brush shall be the quality of SS316 and over.

Peculiarity

• It shall work without electric power.
• It shall not work at ordinary times, but shall work only when thunderclouds are being.
• It shall not radiate radioactive substances.
• The corona shall be previously discharged in opposition to the thundercloud having straight polarity or reverse polarity.

Horizontal Conductor

The horizontal conductor shall satisfy the related regulations or shall have further performance.
The material of conductors shall be singular, multiple and rectangular aluminum cables or pipes.

In case copper is used, the cross section shall be 30mm² (50mm² in the case of aluminum).

The horizontal conductor shall be set up at the place where lightning easily strikes, such as the ridge of the roof, the parapet, the roof and otherwise, and shall be annulations in case it is set up on the slab roof.

The horizontal conductor shall be connected to the pole of the ground wire along the conducting wire.

In case a copper booth bar is used, its size shall be more than 10X3t.

**Conducting Wire**

The conducting wire shall satisfy the related regulations and shall have further performance.

The conducting wire shall be the copper wire of which cross section is over 30mm², the aluminum wire of which cross section is over 50mm² or the material of which conductivity is equivalent to the two.

The conducting wire shall be tightly adhered to the object, by using an aluminum tightener, at regular intervals.

**Ground Terminal Box**

Brass bolts or stainless materials shall be used in the box.

The size of the box and its emplacement shall follow the draft.

The connection bus shall be unitary type made of copper strip, and its size shall be at least 25mm X 3mm.

The ground wire shall be bare copper wire at the secondary of the box.

**Quality of Materials**

The material carried in the field shall be inspected by the superintendent.

Inspection shall be performed to size, structure and otherwise with the naked eye.

**5.1.7.4 Installation**

**Condition**

Lightning protection system shall be installed in conformity with the related regulations.
Lightning Rod

The lightning rod shall be so installed that it can endure strong winds.

It shall not be corroded in any case.

Each connection part shall be treated with stainless material so that it cannot be corroded.

Conducting Wire

Conductors shall be installed along the rooftop and the outer wall, and the single-rod lightning rod shall be connected.

Conductors shall be made of the bare copper wire of 38sq.

The radius of curvature of the ground wire shall be more than 20cm.

Horizontal Conductor

The horizontal conductor shall be tightly fixed at intervals of 1.5m, by using the device made of insulants, and elastic protective conductors shall be used at intervals of at least 30m.

Connection

The connection between a lightning rod and conducting wire, between conducting wires, and between conducting wire and a ground electrode shall satisfy the followings.

All connections related with conducting wire shall be solidly performed by using CAD welding or compressed sleeve, and it shall be free from mechanical, electrical shocks.

The electric resistance of the connection part shall not be higher than the resistance of the same length as the connection part of the conductor itself on the side of higher resistance.

In case different metals are connected, electrical corrosion shall not be arisen at the connection part.

Quality Control

Installation Checkup

- The installer shall check the field after setting up the ground electrode, and shall fill up it with the approval of the superintendent.

- Lightning rods and conductor wire shall be approved by the superintendent after installation.
5. Electronical Specification

5.1.8 Grounding System

5.1.8.1 Scope

The present specifications shall be applied to the grounding installation for buildings or internal facilities in conformity with the related regulations.

Related Specifications

Wires shall be laid in accordance with ‘Indoor Wiring Work’, with the exception of the provisions stipulated in the present specifications.

Submission

Unit Data

Materials of ground wire, size, type and otherwise 2) Arrangement and Connection Plan

Detail Drawing

- Arrangement Plan of Ground electrodes
- Distribution Plan of Ground electrodes
- Other necessary documents

Documents for Completion

- Measurement of Ground Resistance
- Management Plan for Grounding System
- Working Plan

A working plan shall be made out and shall be approved by the superintendent.

5.1.8.2 Reference Standards

The relating standard shall be of NFPA 70, NEC 250, IEC 61024.

5.1.8.3 Material

**Grounding Copper Strip**

The grounding copper strip shall be 16mm in diameter and shall be 1,800mm in length, with the exception of a particular stipulation.
Ground Wire

Ground wire shall satisfy the related regulations, and F-GV wire or the wire equivalent to it shall be used aside from the things laid in the transformer room and the supply room.

Ground wire shall be marked with a green color except the following cases.

- In case ground wire is easily discerned as it is laid independently
- In case that multi-strand cable, multi-strand cabtyre cable or the first insulated conductor of multi-strand code are used for ground wire, and that the insulated conductor is bare wire or is yellowish-green brindle
- In case ground wire, which is not green or yellowish-green brindle, is unavoidably used, its tip or a conspicuous spot shall be marked with green tape.

Sort and size shall follow the draft.

Ground Terminal Box

The outer box shall be STS 304 stainless steel of which thickness is over 1.5mm.

Brass bolts shall be used inside so that copper strip can be fixed.

The connection bus shall be unitary type made of copper strip, and its size shall be at least 25mm X 3mm.

The terminal for subsidiary ground electrode in the terminal box shall be connected with the subsidiary ground electrode so that ground resistance can be measured.

The grounding terminal shall satisfy the related regulations.

Ground electrode

Copper plate, copper bar, steel pipe, steel bar, copper-clad steel plate and carbon-covered steel bar shall be used for burial or insertion-type ground electrodes in principle, and ground electrodes shall satisfy the followings or the things equivalent to those materials shall be used.

Copper plate shall be 0.7mm in thickness and 900cm2 in area (in case it is stretched out).

Copper bar and copper-covered steel bar shall be at least 8mm in diameter and at least 0.9mm in length.

In case copper pipe is used, galvanized steel pipe or thick steel conduit, having the external diameter of at least 25mm and the length of at least 0.9mm, shall be used.
In the case of steel bar, galvanized steel bar of which diameter is at least 12mm and length is at least 0.9mm shall be used.

Copper-clad steel plate shall have the thickness of at least 1.6mm, the length of at least 0.9m, and the area of 250cm$^2$ (one side).

Carbon-covered steel bar shall have the diameter of at least 8mm and the length of at least 0.9m.

**Material Quality**

**Material Inspection**

- The material carried in the field shall be inspected by the superintendent.
- Size, structure and otherwise shall be inspected with the naked eye.

### 5.1.8.4 Installation

#### Conditions

Grounding works shall be applied to all electric works, and shall be carried out in accordance with the related regulations.

In case a fixed resistance value cannot be come out though ground bars were set up in accordance with the draft, ground bars shall be additionally set up until the fixed value is come out or emplacement and method shall be changed.

The emplacement of ground electrode and its main wire shall be correctly marked on the draft, and the resistance value measured after the completion of installation shall be submitted to the superintendent.

As grounding and bonding are remarkably different from each other in purpose and meaning, the two shall not be mingled with each other.

#### Grounding

Grounding works shall be performed in accordance with the common grounding type so that it can be equipotential.

In case ground wire is in danger of being damaged, it shall be put in steel pipe (includes gas pipe) or synthetic resin pipe. However, lightning rod and the ground wire for lightning arresters shall be opened in principle.

The steel-made outer box of electric devices, pipes and otherwise, which need to be grounded, shall be thoroughly connected with ground wire electrically and mechanically.
The connection between ground wires, which are set up in the mesh network, shall follow Extheric Welding.

The main ground wire shall be compressed and connected, by using compressed sleeve in consideration of each region.

The device in which ground terminal, ground bus or ground tap are set up shall be solidly grounded by using suitable tools such as a compressed terminal, a cramp, U-bolt and otherwise, and shall be free from mechanical and electrical shocks.

The connection between ground wires or the connection between ground wire and a device shall not be performed without cramps and terminals in no case.

**Ground Electrode Setting**

Ground electrodes shall be set up at moist places if possible, and shall be buried or inserted in the ground free from gas or acids.

Ground wires and ground electrodes shall be connected by CAD welding. However, lightning rods and lightning arresters shall not be soldered.

In case a steel-made water pipe is used as a ground electrode, the followings shall be satisfied.

In case two ground electrodes and more are parallel connected, their interval shall be 2m and more and it shall be equivalent to the ground wire that is connected to the first ground electrode at the spot 1m deep.

**Value of Ground Resistance**

Equipotential security shall be put first in grounding, and the ground resistance of common ground shall be less than 5Ω

**Quality Control**

Test

The installer shall measure ground resistance in the presence of the superintendent, after the completion of the grounding work, and shall submit the test result to the superintendent.

Installation Checkup

- The installer shall check the field after setting up the ground electrodes, and shall fill up it with the approval of the superintendent.

  - Checkup Items
5. Electronical Specification

The condition of setting ground electrodes
The condition of connecting between ground electrodes
Measuring ground resistance before filling up

5.2 Electrical Facility Instrument Specifications

5.2.1 General Details

5.2.1.1 Outline

Manufacture and Installation of 30kV Extra High Voltage Distribution Board : 1 lot
Manufacture and Installation of Transformer Panel : 1 lot
Manufacture and Installation of 380V Low Voltage Distribution Board : 1 lot
Manufacture and Installation of Generator Control Panel (GCP) : 1 lot
Manufacture and Installation of Mechanical Operating Panel and Local Operation Panel : 1 lot
Spare Parts and Tools : 1 lot

5.2.1.2 Range of Supply

The builder must include detailed plan, purchase of materials, manufacture supply of equipment, transportation, installation, testing, test operation, education and training for all items indicated on the specifications and blueprint. All detailed items that should be naturally included must be executed under the direction of supervisor even if not separately stated in this specification.

5.2.1.3 Conditions for Operation

All equipment must consider the weather conditions of this business area and the characteristics of business site in which the equipment is being operated. All equipment, materials and operations must be made appropriate for such conditions.

5.2.1.4 Electric Power System and Voltage

The voltages for each load are as below.
<table>
<thead>
<tr>
<th>Load</th>
<th>Electricity Method</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra High Voltage</td>
<td>AC 30,000V, 3 phase 4 line type</td>
<td></td>
</tr>
<tr>
<td>Distribution Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low Voltage Load</strong></td>
<td>AC 380V/220V, 3 phase 4 line type</td>
<td></td>
</tr>
<tr>
<td><strong>Vision Imaging System</strong></td>
<td>AC 220V, single phase 2 line type</td>
<td></td>
</tr>
<tr>
<td><strong>Control System</strong></td>
<td>AC 220V, single phase type line type or DC 110V</td>
<td></td>
</tr>
</tbody>
</table>

### 5.2.1.5 Equipment Label

**Warning Sign**

The builder must record the warning sign and each equipment symbols using the form and text determined by supervisor.

**Device Number**

All electrical operation switches, relays and other equipment must be attach the serial number of the equipment at the detailed circuit diagram of production map and the contactor must attach the regulation label marked by number to all equipment.

**Label**

The builder must attach labels to all parts of the equipment to make operation and maintenance simple. These labels must be made of plastic or iron materials. The text of all labels must be submitted to the supervisor to get approval and the text must be in English.

### 5.2.1.6 Paint

All exposed surfaces of panel and other steel products must be epoxy electrostatic blast painted after rustproof processing, the paint being used must be durable to moisture or salinity and must be the one that can endure long period of usage. The final paint color of all equipment must get the approval of the supervisor and the contractor must get the approval for sample color on the equipment by submitting its color plan.
5. Electronical Specification

5.2.2 Extra High Voltage Distribution Board

The extra high voltage distribution board is for 30kV electrical power systems.

5.2.2.1 Mode

The extra high voltage distribution board is indoor enclosed and uses cubicle type as distribution board.

Extra High Voltage Distribution Board Panel List.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Panel Name</th>
<th>Particular of Items</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>EHV-01</td>
<td>30kV LBS &amp; LA PANEL</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>EHV-02</td>
<td>30kV PF &amp; VT PANEL</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>EHV-03</td>
<td>30kV MAIN VCB PANEL</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>EHV-04</td>
<td>30kV MOF PANEL</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>EHV-05</td>
<td>30kV VCB PANEL</td>
<td>1</td>
</tr>
</tbody>
</table>

Related Standards

IEC 60044, 60255, 60265, 60282, 60298, 60466, 60529, 60697, 62281

5.2.2.2 Structure

The distribution board case is indoor closure independent type, manufactured firmly as rolling steel material for general structure of more than 2.3mm, and the finished product must be Angle less Type as metallic closed type that can connect 2 or more sides of panels.

This distribution board is simple, plain, and must use the structure to have excellent electrical, thermal, and mechanical properties as well as the structure that can safely and easily perform normal operation and maintenance inspection.

The manipulation of circuit breaker is operated as three phase in unity, equipped with electric spring manipulation function and must be motor driven type structure to enable remote control.

The material which is appropriate for rated current must be used for the conductor.

By preparing ground terminal at Channel Base, the case must be grounded.

The connection with main transformer must be by cable.
The equipment type must be the one having appropriate structure and performance for each equipment standards.

The control compartment that has received control and auxiliary equipment should be separated to metal partition wall which is grounded with main circuit and the wiring of auxiliary circuit must be as the structure using duct.

5.2.2.3 Electric Power Cable Terminal and Booth Connection

The cable is entered and existed through lower part of distributing board, must be equipped with the device that can supply non-magnetic cable grand board without hole at the entrance, must have enough space for terminal processing of electric cable and must be equipped with a device that can connect ground wire.

The electric booth is 3 phase copper booth, the connecting section must be silver plated, its rating must not be less than the circuit breaker with highest rating among installed circuit breakers, use inorganic or organic flame retardant to fit the voltage rating for insulation supporting article and must identify and insulate the phase using heat contraction tube, etc. as the supporting article to adequately endure the shock, etc. that can easily occur during short circuit.

The connection with equipment accompanying vibration must be connected as flexible bus.

5.2.2.4 Operation and Switching Device (When Necessary)

Regular

It must be of Rotary Type which closes the point of contact by rotating the handle.

The fixed and mobile contact point must be made to correspond and stick completely during contacts using spring and the mechanical intensity must be sufficient.

The handle of switch must have enough insulation as the one which is firm and heat curable without flexibility using molded plastic. The name plate is attached to the surface.

Operation Switch for Circuit Breaker

The contact point rating must be DC 110V electric current and successive rating must be 20A.

It must be momentary contact type that has the spring to restore the handle and contact point to original position at "ON" or "OFF" position.

The shape of handle is pistol grip type, must have position indicator which indicates nameplate and open/shut status at the surface and also must possess 1 or more contact
5. Electronical Specification

points.

Transfer Switch for Gauge

The contact point rating must be AC 300V and successive rating must be 10A.

The transfer mode is manual restoration method and must be multipolar successive contact type. The one for ammeter transfer must have structure of over-lap contact point to prevent opening the CT circuit.

The shape of handle is round notched type and must have indicator which indicates the name plate and measuring image at the surface.

5.2.2.5 Gauge-Relay

All gauges and relays attached to the front of panel must be installed as flush or semi-flush type.

The indicator type gauge and relay must be digital type.

The protective relay attached to the front of the panel must include a device to short-circuit the CT circuit to perform complete testing and correction without affecting other related circuits at the attached position.

The transformer circuit must be automatically shorted at the time of lifting the relay from the case.

The protective relay must possess operation indicator and must be able to reset at the front of the relay.

Each protective relay must be equipped with the setting range enabling mutual aid.

5.2.2.6 Auxiliary Contact Point

The auxiliary contact point (circuit breaker and relay) must be provided by adding at the contact point necessary for operation and also must be wired to the terminal block so it can be used by operation workers in the future.

5.2.2.7 Terminal Block, Control Circuit Wiring

The testing terminal must be installed at CT and the circuit at the second PT to make the testing of gauge and relays convenient and a name plate indicating the trade name must be attached at the upper part of the terminal.
The terminal block is a unit type of 380V rating and must be the type which fastens the terminal with screw.

The terminal should be the voltage terminal that can connect the conductor with maximum linear diameter of $6\,\text{㎟}$ in case of regular wiring and maximum linear diameter of $10\,\text{㎟}$ in case of CT wiring.

The terminal block should be attached to easily connect the terminal section and must be able to identify the terminal number easily. Also, the auxiliary contact point of circuit breaker and contact point of relay being drawn out from the distribution board must be wired at the terminal block and the terminal must have 20% surplus.

The wire prescribed at the related standard is used for the control circuit as a rule. The cross section of wire used in control circuit is more than $1.5\,\text{㎟}$ as a rule.

For the color of wire coating, the main circuit is black, control circuit and others are yellow, ground wire is green and extra wires such as shield wire don't have to follow this coloring.

Wiring Method

The inner wiring of distribution board and corresponding wiring are as below.

Wiring Method

Duct wiring method as a general rule and bundle wiring in case of operation section.

Fixed Section Structure of Wiring

For the fixed section of wiring, it must be the structure which the metal parts do not directly give voltage.

Terminal Connection Method of Wiring

The terminal connection of wiring must be made to not create contact error, connection carry off and short circuit.

Placement of Wiring

The equipment or placement of conductor, each terminal and testing terminals, etc. must be placed according to related regulations seen from the front.

5.2.2.8 Indication Lamp (When Necessary)

The indication lamp showing open/shut status of circuit breaker and switch must be installed at each side of the distribution board. Also, these lamps must be enable the exchange of bulb at the front without opening the door.
5. Electronical Specification

**Power Supply**
DC 110V

**Indication Lamp**
Marks the close circuit as green, open circuit as white, malfunction as yellow and must use LED type for the bulb.

5.2.2.9 **Grounding**
The grounding booth must be attached 50mm above the lower base of the distribution board and must possess ground wire connection terminal at the end of grounding depot while attaching the connecting plate that can easily connect to nearby grounding depot.

The wire more than $6.0 \text{㎟}$ must be used for second grounding of transforming converter for gauges.

Each unit metal case must be electrically connected with grounding depot.

5.2.2.10 **Auxiliary Equipment**

**Circuit Breaker**
- Type : Vacuum Circuit Breaker (VCB)
- Rated Voltage : 30kV
- Rated Current : 630A
- Rated Breaker Current : 20kA
- Circuit Breaking Time : 5Cycle
- Trip Method : Shunt Trip
- Installation Method : Stationary type
- Operation Voltage : DC 110V

**Arrester (LA)**
- Type : Gapless Type
- Official System Voltage : 30kV
Detailed Design for Muvumba Multipurpose Dam

**Official Discharge Current**: 10kA

**Material**: Zinc Oxide (ZnO)

**Surge Absorber (SA)**

The surge absorber must be made to protect mold transformer from open surge created while inserting the circuit breaker.

**Type**: Gapless Type

**Official System Voltage**: 30kV

**Discharge Withstand Capacity**: 10kA

**Material**: Zinc Oxide (ZnO)

**Power Fuse (PF)**

**Type**: 1P, single throw, indoor type

**Rated Short Time Current**: The amount that can endure short time current of the system

**Rated Voltage**: 30kV

**Rated Current**: 200AF (1A Fuse)

**Accessories**: Must possess all necessary accessories.

**Potential Transformer (PT)**

**Type**: Indoor Epoxy Mold

**Rated First Voltage**: 30,000V

**Rated Second Voltage**: 110V

**Rated Burden**: Determined based on corresponding circuit burden

**Error Class**: 1.0 Class

**Current Transformer (CT)**

**Type**: Indoor Epoxy Mold

**Rated First Voltage**: Refer to drawing
5. Electronical Specification

Rated Second Voltage : 5A

Rated Burden: Determined based on circuit burden corresponding as at least more than 40VA

Error Class : 1.0 Class

Digital Protective Relay

Definitions

• Protection function

It has all of protection function of existing guidance type protective relay and accordingly, various functions of protective relay such as OCR, OCGR and UVR, etc. must be processed with one digital protective relay.

• Status monitoring

The digital protective relay must be able to indicate various information (operation status of OCR, OCGR and UVR, etc.) performed within protective relay and must support the function of being able to watch the status remotely.

• Control and Interlock

The digital protective relay must have the interlock function to open the circuit breaker by getting the trip signal from the protective relay by interlocking with circuit breaker and must support the function of inserting/opening the circuit breaker remotely using digital protective relay.

Standards

• Protective Relay Section

Input Standards

• Input frequency range : 50Hz

• Input voltage range : PT 110V

• Input current range : CT 5A

Communication Standards

• The digital protective relay must support the communication standards to enable remote monitoring and control using the computer of monitoring control equipment provided by other equipment suppliers and must be made to enable smooth data
link by opening the communication protocol.

- **Measuring Section**

  **Input Standards**
  - **Wiring Method**: 3 phase 4 line type
  - **Frequency Input Range**: 50Hz

  **Measurement Value Indication Items**
  - Voltage, current, effective voltage (W), effective amount of voltage (WH), power factor, frequency.

- **Control Section**

  It must provide input and output control functions to control the circuit breaker.

  - **MMI Section of Protective Relay**

  The digital protective relay must be composed to enable observation and control of corresponding electrical equipment as well as the status of protective relay.

**Structure and Performance**

- **Protective Relay Section**

  **Operation Features**
  - Protective operation features of OCR, OCGR and UVR, etc.
  - Should have operation classifying function of momentary and long-term factors.

  **Relay Select Function**
  - The digital protective relay must have the function for random selection of various protective functions.

- **Measuring Section**

  **Input and Output of Contact Point**
  - Must provide the output contact point to interlock the trip signal of digital protective relay to circuit breaker, etc.
  - Must provide the output contact point for observing various statuses at remote observation control equipment.

- **Control Section**
5. Electronical Specification

It must provide the output contact point to control the circuit breaker interlocked with digital protective relay.

- Other

The digital protective relay must be the structure that can be attached to the door of distribution board and the indicating or operating section must be exposed.

The RS-485 communication route for communication between digital protective relay and RCS (supplier's supply of observation control equipment) must perform cable supply, building and testing by supplier.

The digital protective relay must have enough electrical and mechanical durability and must not malfunction because of external noise.

The digital protective relay must be the structure to have enough electrical and mechanical durability using materials of high quality, the operation must be smooth and reliable, have low shock and easily and safely perform external inspection required at the installed state.

The digital protective relay must protect loading equipment by the interlock function of various protective relays.

It must be the structure of easy maintenance.

It must be the structure that can effectively use the panel installation space by being small and lightweight.

Automatic Fire Extinguisher of Distribution Board

The automatic fire extinguisher of distribution board must be installed at the top or back of electric room panel.

Specification : Panel individual type

Extinguisher Chemical : Pure extinguisher chemical (NAF S-III), government authorized product

Accessories : Required parts such as heat detector, smoke detector and fire extinguisher release head, etc.
5.2.3 **Transformer**

5.2.3.1 **Type**

Built-in cubicle, indoor, independent, Mold Type

The transformer panel list

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Panel Name</th>
<th>Particular of Items</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Main TR</td>
<td>30kV/380V TRANSFORMER PANEL</td>
<td>1</td>
</tr>
</tbody>
</table>

Related Standards

IEC 60076, 60214, 60296, TR 60034-108-22, 60186, 60783

5.2.3.2 **Iron Core**

The iron core must strive for improvement of non-loading features and minimize the voltage loss and exciting current using directional silicon steel plate of magnetic permeability without secular changes.

The connection of iron core must be made to have satisfactory magnetic and exciting features.

5.2.3.3 **Coil**

The epoxy resin where the conductor for coil of this transformer has been molded must have fire extinguishing features by itself and the resin being used must apply pure epoxy with very excellent heat resistance. Also, all insulation structures must use materials that are highly resistant to flame and the heated resin or insulator must not melt or expand from the point of fire outbreak.

The epoxy resin itself where conductor for coil has been molded must have strong durability features so that the moisture from surrounding environment enables simple cleanups during periodic maintenance inspections by reducing sedimentation of impurities such as dust and not require repair plans such as separate supplementary drying operations by minimizing the effects on electrical properties such as reduced insulation.

All insulation materials and component materials used in this transformer must select the exclusive parts corresponding the extra nature of mold transformer to prevent creating sudden accidents caused by insulation heat.
High and low voltage coils must be molded with epoxy resin and must be able to effectively perform the heat dispersion of coil between high and low voltage coils by cooling duct.

5.2.3.4 Thermometer
The digital type thermometer must be prepared at the transformer and this must be confirmed easily from the outside by being installed at the cubicle.
Thermometer must possess alarm and contact point for the trip while being wired up to terminal block for external wiring.

5.2.3.5 Anti-Vibration Device
The anti-vibration rubber must be installed between main body and bottom base in order to suppress the transmission of vibration created at the transformer.

5.2.3.6 Grounding Terminal
The grounding terminal must be installed at the appropriate position at the bottom of transformer.

5.2.3.7 On Voltage Tap Insulation Terminal
The on voltage tap insulation terminal for insulation and slowdown of the tap is installed at the extra high voltage side, must be structure that can manually insulate from the outside and must be the structure to easily find out the wiring position of taps by each voltage.

5.2.3.8 External Case
The external case of transformer board is indoor enclosed type with sound ventilation, produced firmly as material of general structure rolling steel with thickness of 2.3mm or more, the finished product must be independent type in which the shape doesn't get twisted or transformed while handling or using it and must not vibrate from magnetism.
The external case must be equipped with door attached by hinge and must consider interior illumination and door stopper interlocked with opening of the door.
The manufacturer rating fan must be installed for heat dispersion of inside at the top or back of external case and must be the structure that can prevent the invasion of animals such as rats.
It must be equipped with auxiliary devices so that the vibration of transformer doesn't get
transmitted to the external case while the terminal of transformer and connection of main bus bar must be made to not get transmitted to the leading line using flexible bus.

5.2.3.9 Accessories

It must supply and install accessories that are necessary in operation of transformer including below accessories.

Thermometer (Contact point attaching type)
Anti-vibration Rubber
PTC Thermistors and Relay Unit
Non-voltage Tap Insulation Terminal
Grounding Terminal

5.2.3.10 Ratings

Main Transformer

Rated First Voltage : 30kV
Rated Second Voltage : 380V
Tap insulation method : OLTC
Used Rating : Successive
Cooling Method : Self-cooling

By insulation type
1st coil : Type B or better
2nd coil : Type B or better

Temperature Limit
1st coil : 80℃
2nd coil : 80℃

Insulation Intensity (First Side)
Common frequency withstand voltage : 50kV
5. Electronical Specification

Impulse withstand voltage : 95kV
Percentage impedance : 6% or under

5.2.4 Low Voltage Distribution Board

5.2.4.1 Type
The low voltage distribution board of 400V or under should be indoor closure independent type.

Low Voltage Distribution Board Panel List.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Panel Name</th>
<th>Particular of Items</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>LV-A</td>
<td>380V ACB PANEL</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>LV-M</td>
<td>3800V ACB PANEL</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>LV-1</td>
<td>380V MCCB FEEDER PANEL</td>
<td>1</td>
</tr>
</tbody>
</table>

Related Standards
IEC 60269, 60694, 60298, 60466, 60529, 60694

5.2.4.2 Structure
The external case of distribution is indoor closure independent type with good ventilation, produced firmly as cold rolled steel material of 2.3mm or more, the finished product must be independent type which its shape doesn't get twisted or transformed while handling and using it and must not be vibrated from magnetism. But the door must be more than 3.2mm and distribution board case must be equipped with lifting lug that can be separated

Each distribution board must be equipped with a door attached by hinge and also must install internal lighting which interlocks with opening/shutting of the door, rated space heater appropriate for manufacturer specification to each side and the door stopper.

The circuit breaker, each interval of main bus bar and switch must be accommodated within a separate metal board in order to implement adequate electrical isolation.

The ventilation louver must be equipped with a net to prevent trespassing of insects or small animals and must not make a hole for the purpose of ventilation between adjacent sides.

At the front and back of exposed recharge part within the case, the metal protective net, etc. must be installed in order to prevent contact of human body.
5.2.4.3 Rating
Rated voltage : AC 400V
Rated short-term current : The capacity that can endure short-term current of the system

5.2.4.4 Power Cable Terminal and Booth Connection
Corresponds to 2.2.3 "Electric Power Cable Terminal and Booth Connection" of 30kV extra high voltage distribution board.

5.2.4.5 Key Equipment
Air Circuit Breaker (ACB)
Type : Withdrawal type air circuit breaker

Ratings
Rated voltage : 380V
Rated current : Refer to drawing
Operation power : DC 110V
Input operation method : Motor operation
Trip method : Voltage trip

Operation Features
• There must be service position and test position at the cubicle of circuit breaker.
• The electric spring must be charged automatically if circuit breaker is at the service position.
• It must enable charging with manual operation when it can't be charged with motor operation.
• The circuit breaker must not draw out at a closed state.
• The circuit breaker must be automatically discharged while drawn out in a spring charge state.
• The circuit breaker closed from the outside must be automatically opened before being projected to service position.
• The circuit breaker spring charged from outside must be automatically discharged.
5. Electronical Specification

before being projected to service position.

• The operation instrument of circuit breaker must be equipped with reliable electrical and mechanical trip free instruments.

• The operation instrument must be equipped with manual operation devices such as lever that can project and trip 3 or 4 poles of circuit breaker at the same time.

General Structure

• The structure of circuit breaker must be firm, the electrical and mechanical performances must be durable using material of good quality and should be the withdrawing type. The operation must be performed smoothly and surely, have low shock and the maintenance inspection must be made easy.

• Main circuit disconnection section

  The withdrawal type circuit breaker should be the one with attachment/detachment of main circuit at the recharging section without using hands by installing automatic connection type disconnecting section at the main circuit. The circuit breaker must maintain enough stable condition toward electromagnetic power or vibration and must be the structure that doesn't have possibility of creating bad movement or contact and wouldn't be moved from vibration also at the disconnection circuit (testing) section. The position of main circuit breaking section that cannot be confirmed with eye should indicate each position of disconnection circuit (testing). The main circuit after drawing out the circuit breaker should have the mark called bus side near the fixation side to easily identify the position of withdrawal side.

• Control circuit disconnection section

  The control circuit of withdrawal type breaker must install disconnection section of manual connection as a rule. The manual connection type disconnection section must be the one without possibility of failed connection and must not have the possibility of creating short-circuit accident or shock injury by exposing the recharging section even if it has been exposed. While using automatic connection type disconnection section, it gets connected automatically by the operation of projecting the circuit breaker without touching the recharging section with hands, the control circuit disconnection section cannot be opened artificially at the state of being connected with main circuit and should enable connection (testing position) and opening (disconnecting position) at the state of being disconnected with main circuit.

• Frame grounding contact

  The main circuit disconnecting section must be securely connected until the disconnection distance by automatic connection method.
Compatibility

The built-in withdrawal type circuit breaker should be the one having mutual compatibility with other withdrawal circuit breakers of same rating as same type by same manufacturer.

Accessories

It must supply required accessories such as trip indication switch, key lock device, auxiliary contact point and open counter.

Wiring Circuit Breaker

Type: Mold case, thermal electromagnetic type, protection of excessive current and momentary short circuit current protection function circuit breaker Ratings

- Rated voltage: 380V
- Nominal voltage: 380V
- Rated current: Refer to drawing
- Rated short circuit current: Refer to drawing

Accessories

The circuit breakers requiring auxiliary contact point and trip signal contact point must be equipped with these things.

Static Condenser

- Type: Indoor sealed type
- Phases: 3 phase
- Rated voltage: 380V
- Other: Must supply the required accessories including the device to discharge remaining electric charge of open circuit such as discharge coil.

5.2.4.6 Operation and Transfer Switch (When Necessary)

Corresponds to 2.2.3 "Electric Power Cable Terminal and Booth Connection" of 30kV extra high voltage distribution board.
5.2.4.7 Gauge-Relay
Corresponds to 5.2.2.5 "Gauge-Relay" of 30kV extra high voltage distribution board.

5.2.4.8 Auxiliary Contact Point
Corresponds to 5.2.2.6 "Auxiliary Contact Point" of 30kV extra high voltage distribution board.

5.2.4.9 Terminal Block, Control Circuit Wiring
Corresponds to 5.2.2.7 "Terminal Block, Control Circuit Wiring" of 30kV extra high voltage distribution board.

5.2.4.10 Indication Lamp (When Necessary)
Corresponds to 5.2.2.8 "Indication Lamp (When Necessary)" of 30kV extra high voltage distribution board.

5.2.4.11 Grounding
Corresponds to 5.2.2.9 "Grounding" of 30kV extra high voltage distribution board.

5.2.4.12 Accessories
Corresponds to I)"Accessories" of 30kV extra high voltage distribution board.

5.2.5 Generator Control Panel (GCP)

5.2.5.1 Type
Generator Control Panel (GCP) should be of indoor independent sectional panel.

Generator Control Panel List.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Panel Name</th>
<th>Particular of Items</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GCP-1-1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>GCP-1-2</td>
<td>Induction Generator #1</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>GCP-2-1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>GCP-2-2</td>
<td>Induction Generator #2</td>
<td>1</td>
</tr>
</tbody>
</table>
5.2.5.2 Structure

GCP must be equipped with main circuit switch and control device by each unit circuit to control and protect the resistance load with the motor connected to the track of 400V or less.

The load terminal and control terminal must be made to connect at the terminal board within GCP.

The horizontal and vertical buses must be made to endure mechanical shock from short circuit current.

The front door of unit must be equipped with internal hinges.

The control circuit wiring of each withdrawal unit should use the plug type connector.

control center must be equipped to make transportation and installation easy.

5.2.5.3 Power Cable Terminal and Booth Connection

The cable is entered and existed through lower part of GCP, must be equipped with the device that can supply non-magnetic cable grand board without hole at the entrance, the electric compartment of each side must have adequate space and must be equipped with a device that can connect ground terminal.

The electric booth is 3 phase copper booth, the connecting section must be silver plated, its rating must not be less than the circuit breaker with highest rating among installed circuit breakers, use inorganic or organic flame retardant to fit the voltage rating for insulation supporting article and must identify and insulate the phase using heat contraction tube, etc. as the supporting article to adequately endure the shock, etc. that can easily occur during short circuit.

5.2.5.4 Gauge·Relay

Corresponds to 5.2.2.5 "Gauge·Relay" of 30kV extra high voltage distribution board.

5.2.5.5 Terminal Block, Control Circuit Wiring

Corresponds to 5.2.2.7 "Terminal Block, Control Circuit Wiring" of 30kV extra high voltage distribution board.

5.2.5.6 Grounding

Corresponds to 5.2.2.9 "Grounding" of 30kV extra high voltage distribution board.
5. Electronical Specification

5.2.5.7 Auxiliary Equipment (When Necessary)

Potential Transformer (PT)
- Type : ABS Resin
- Rated 1st voltage : 380V
- Rated 2nd voltage : 110V
- Rated burden : Determined based on corresponding circuit burden
- Error class : 1.0 Class

Current Transformer (CT)
- Type : ABS Resin
- Rated 1st voltage : Refer to drawing
- Rated burden : Determined based on corresponding circuit burden
- Error class : 1.0 Class

Auxiliary Relay
It must be LED attachment type built-in to the plastic case as Plug-in Type or magnetic contactor type.

Blackout Condenser
- Type : Indoor sealed type
- Phase number : 3 phase
- Rated burden : 380V
- Other : Must supply necessary accessories
5.2.5.8 Digital Motor Protection Device

Type

It must concentrate various meters, protective relay, operation and transfer switch, lamp and communication unit, etc. as a device of 1 unit.

It must be able to adjust settings such as system constant, PT rate and CT rate, etc. voluntarily.

There must be On/Off manipulation of switch and a switch to select MCC/Local/Remote options.

There must be LED indicator lamp to show the operation status of protective relay.

All Metering of generator control panel (GCP) must be concentrated as digital marks.

Data communication, distant control and observation must be made possible.

The relay factor of generator control panel (GCP) must enable automatic and manual setup.

Key Functions

Relay Functions

• 3 phase current
• Voltage
• Effective power source
• Power factor
• Frequency

Protection Functions

• Protection of excessive current
• Protection of disconnection phase/unbalance
• Protection of inverse phase
• Protection of ground
• Protection of lock

Control Function : On/Off
5. Electronical Specification

Indicator Function

- Centralized indication of relay operation status and circuit breaker status with front LED
- Indication of digital relay value
- Malfunction data when breakdown occurs

Communication Function

- Communication method: RS485/RS422 Modbus
- Connection method: 2Wire or 4Wire Multi drop
- It must support the protocol applied at observation control equipment in order to interlock with observation control equipment.

Requirements

- Type: digital type, purchase type
- Burden: 5VA or under
- Control power source: AC 220V, 50Hz

5.2.6 Mechanical Operating Panel & Local Operation Panel

5.2.6.1 Type

The Mechanical Operating Panel and Local Operation Panel must be manufactured by being selected from the following types depending on installation site and operation functions.

Mechanical Operating Panel and Local Operation Panel List.

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Panel Name</th>
<th>Particular of Items</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MOP-401</td>
<td>Oil Supply System #1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>MOP-402</td>
<td>Oil Supply System #2</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>MOP-403</td>
<td>Cooling Water System #1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>MOP-404</td>
<td>Cooling Water System #2</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>MOP-405</td>
<td>Air Supply System</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>LOP-201</td>
<td>Drainage Pump</td>
<td>1</td>
</tr>
</tbody>
</table>
5.2.6.2 Structure

The local operation panel types are the same as its detailed map shown on the blueprint.

The local operation panel must be made with thickness of STS 304 1.5mm or more. (But the door is 2.0mm or more)

The handle with lock and hinges at the inner side must be installed for the panel door.

All gauges, indicator lamps and control equipment, etc. should be installed at the inner wall of panel and also must be the structure of easy observation without opening the door.

The local operation board must be the structure which is protected from moisture, dust and corrosive substances and especially must be the structure that is not influenced by rain or sunlight in case of outdoor type panels.

The local operation panel installed at the site influenced by corrosive gas must be made as dual door type that can observe the status through sight glass.

In case of pipe support type local operation panel, the support pipe must be able to adequately accommodate the incoming and outgoing cable as STS steel pipe with minimum diameter of 100F or more, the material of base plate should be STS steel plate of 5t or more and the base should be 300×300mm or more.

While selecting remote operation (Remote) at the local operation panel, the circuit must be configured to recognize its status at the center.

All local operation panels must be installed on concrete foundation of 50mm or more and anchor bolt and nut, etc. for attachments must use STS materials.

5.2.6.3 Operation Switch

The operation switch is dimmer type push button method and the operation contact section must use metal materials that are durable to high conductivity, abrasion and arc.

5.2.6.4 Terminal Block, Control Circuit Wiring

Corresponds to 5.2.2.7 "Terminal Block, Control Circuit Wiring" of 30kV extra high voltage distribution board.

5.2.6.5 Indicator Lamp

The indicator lamp showing operation and breakdown status of the motor must be installed at the local operation panel.
5. Electronical Specification

- Power : AC 2
- Type : Round lamp
- Indicator Lamp : Operation-green light, halt-white light, breakdown-yellow light

5.2.7 Spare Parts and Tools

The following spare parts and tools must be supplied for the operation and maintenance management of the equipment.

5.2.7.1 Spare Parts

- Control Circuit Fuse : 20 Diazed Fuse 2A
- Aux Relay : 20 AC 230V
- MCCB
  - 15 3P 50AF (Standard Type), 3 3P 100AF (Standard Type)
  - 13P 225AF (Standard Type), 1 3P 400AF (Standard Type)
- Electronic Contactor
  - 5 Standard Type 9A, 1 Standard Type 12A, 1 Standard Type 18A
  - 1 Standard Type 22A, 1 Standard Type 32A, 1 Standard Type 40A
  - 3 Standard Type 50A, 1 Standard Type 65A, 1 Standard Type 220A
- Circuit Breaker
  - 5 3P 30AF, 2 3P 50AF
- Selector S/W : 5 2 bundle, 2a 2b 25Ø
- TB : 10 assembling type, 10P
- Digital Motor Protection Device : Extra high voltage/high voltage/low voltage 2 each

5.2.7.2 Repair Tools

- Coating Removal Plier : 6", 8" 1 each
Detailed Design for Muvumba Multipurpose Dam

- Radio Cutting Plier: 6", 7" 1 each
- Electric Drill: 1 6.5mm, 13mm
- Nipper: 6", 7" 1 each
- Wire Cutter: 1 325㎟
- Exchange Type Driver: 1 6pack
- Hydraulic Pipe Bender: 1 14 ~ 325㎟
- Soldering Iron: 100/300/500W 1 e
- PF Meter (simple type): 2 3 phase AC400/230V
- Leakage Ammeter: 2
- DC Voltmeter: 2
- Insulation Hat: 3 extra high voltage hats
- Ladder: 1 8m
- Tool Box: 1 Set
- Lifter: 1
- GAS Inlet: 1 for GIS
- Voltage Gauge: 1 for GIS
- Voltage Switch: 1 for GIS
- Multi-Tester: 2 Digital
- Grounding Resistance Meter: 1 0~1000Ω
- Insulation Resistance Meter: 1 1000MΩ /2,000MΩ
- Illumination Meter: 1 Portable solar battery
- Leak Detector: 1 300mA~30A
- Electroscope: 1 for high voltage
- Electroscope: 1 for extra high voltage
- Tool Storage Case: Iron 1 Set
5.3 Measuring Control Equipment and Material Specifications

5.3.1 General Details

5.3.1.1 Outline

This is a standard specification for general supply and installation work of measuring control equipment and sets the purpose as regulating technological standard of supplied equipment and their installation.

The adequate preparation and planning must be accomplished so there wouldn't be any obstacles between different equipment in the installation work of measuring control equipment.

The piping work for measuring control should be adequately negotiated with other equipment and the required necessary blueprints must accomplish adequate agreement between these equipment.

The builder must supervise entrance and safety of all workers and becomes responsible for storage of materials and equipment at the site.

The builder must hire skilled people so that workers can perform all operation adequately and securely.

The builder must set preliminary preparation and period that are necessary for making holes, piping, preparation of accessories, installation of measuring control equipment and attaching other attachments firmly. The details not mentioned in this specification shall conform to related regulations.

5.3.1.2 Scope of Application

Any special details or details not stated on the blueprint shall follow this specification.

Because this specification applies to the entire installation, only the applicable clauses are applied for partial installations.

This installation must be operated without infringements of related law.

In case the blueprint of this installation is different from the related law, the installation must be performed in accordance with related law.

5.3.2 Monitoring Control Equipment

5.3.2.1 System Outline

This system is the one having functions of monitoring the entire system, establishing the
multiple data transmission system of operation and measuring signals as well as centralized monitoring and dispersed control, must be consisted of PLC equipment requiring real time monitoring and real time control while the System must be consisted of programmable logic controller (PLC) with built-in operator exclusive operator workstation (OWS) which is man machine interface (MMI), engineering workstation (EWS) and dispersed control processor. Therefore, the H/W and MMI software of same type must be used in order to raise reliability, effectiveness and maintenance of the system.

This system must be designed to be operated in Windows environment and must be the system that has reinforced the convenience of operator even more by using all functions provided in the latest operating system such as multi-tasking in industrial automation.

OWS must be the one that has extra capacity to enable system adjustment depending on necessity from sequence control system of the control system to data collection system and must be used in intensive monitoring and control.

PLC must enable sequence control and loop control, configured so that the partial defects do not spread to overall system, maintains monitoring and operation as well as process control functions, composed of the system that can ensure reliability, grounded by considering the safety of overall system toward falling and surge voltage, etc. and install arrester for the protection of meter and signals.

This PLC System must be made easy for increase and expansion of facility as well as functional reinforcement by adopting widely used OS (Windows) and LAN communication method and must be the open system architecture enabling mutual interface with upper computer and other systems.

Related Standards

IEC 60051, 60297, 60529, 60848, and 61131, IEEE 802.3, NEMA PB1-197, ISA S18.1, S5.5, and RP 60, and ISO 11064

5.3.2.2 Technological Requirements of Monitoring Control System

This system must satisfy the following technological requirements.

Extensibility

It must be planned and designed for easy extension, modification and corrections required in the future.

Monitoring Ability

The detailed management of equipment and overall installations must be made possible for the improvement of monitoring function while status monitoring and control toward overall water treatment equipment system and power system must be made possible at the central...
Operational Ability

This system must enable active and simple operation function for its improvement and because all water treatment facilities are attempted to be monitored and controlled with standardized method at the central control for the overall management of effective water treatment, it must improve the data collection and handling abilities by importing remote measuring facility and data handling facility and contribute to rationalization of operation management.

Integrated Monitoring and Controllability

An open type system which is easily compatible with other models during batch monitoring controls must be designed, supplied and planned while a demonstrative and technological compatibility plan must be presented for this.

5.3.2.3 Software

The software exclusive for water treatment which corresponds to specified and required functions of the specification must be supplied, the application software is composed of programs that are required in supporting specified functions required for this business, can be changed during construction, the builder must submit all execution and source files of finally determined application software upon completion of the installation and also, the input and output devices of the program must be implementable in English for convenience of maintenance and execution of program. The following software should be submitted, but not limited to these.

- Data Collection and Storage Software
- Process Monitoring Software
- Screen Indicator Setup and Operation Software
- Report and Record Printing Software
- Equipment Operation Support Communication Software
- Operator’s Guide Software
- Total Mean Calculation Software
- Other Required Software
5.3.2.4 The Function of Monitoring Control System

The functions required for this system are as follows.

**System General**

All functions provided in the latest operation system such as multi-tasking must be useable by being designed to be operated in Windows environment. The monitoring control system is composed of Operator Workstation (OWS), Engineering Workstation (EWS), Programmable Logic Controller (PLC), the printer which is a peripheral device and the data way connecting these things while OS must enable the system configuration in various forms as a station providing powerful Graphic User Interface (GUI) to the user. Also, the system components must be easily interfaced with upper computing devices or other systems by being connected as high speed Data Way of various types.

**Monitoring Function**

It must be able to monitor everything on status or trouble toward measurement control equipment, various other equipment and monitoring control system itself. If defects or other abnormal situations occur, its details must be indicated without delay and the guideline on its counterplan must also be indicated.

**Control Function**

The related equipment of above as Generator Control Panel (GCP), Programmable Logic Controller (PLC), Operator & Engineering Workstation (OWS & EWS) must perform the functions related to all operations such as monitoring and operation, automatic and interlock, local and remote, Sequence, Analog, PID control and transmission, etc. with one single system.

**Recording Function**

It must be able to collect various data that are necessary in managing water treatment equipment and electric power equipment while being able to record events on trouble and operations by an operator.

**Data Piling Function**

It must be able to preserve flow rate, water quality, power supply and other useful data that are necessary in effective system management and improvement of disposed water quality must be preservable.

**Emergency Operation Function**

The automatic operation must be executable using input program of remote control station even when the communication line or operator station is down.
Down Loading Function

It must be able to store various parameters, database and control programs into internal memory by transmitting to remote control station from engineering station and must be executable.

Alarm Function

In case something goes wrong during status monitoring and control of equipment, the alarm and indication must be enabled by separating the troubles according their levels.

5.3.2.5 System Configuration of Monitoring Control Equipment

This equipment enables information gathering, loop control and sequence control toward corresponding equipment at the Programmable Logic Controller (PLC) while these monitoring control signals are transmitted to operator station located at the central control room through high speed LAN to perform remote controlled monitoring of entire disposal system at the center. The remote control station of this disposal center must be composed to enable control by each process and composed so that monitoring and control on entire equipment are accomplished through operator workstation (OWS) of central control room.

System Architecture

The monitoring control equipment imported to this equipment must have the following system features.

Functional Dispersion

The separated use of computer and controller must be possible depending on the function.

Loading Dispersion:

In must have standardization of each processing ability, reduction of software quantity and extensibility of system.

Risk Dispersion

It must be made to reduce the effect of partial breakdown on the entire system.

Outline of Components

The functions of main devices for monitoring control equipment must satisfy the following.

• Network Communication

   It must use the communication network for exclusive process control as data
communication and must have enough rapidness and promptness as high speed communication of 10/100Mbps or higher as exclusive communication circuit connecting equipment.

- **Operator Station**

  As man interface equipment in which the operator can communicate with process system, the graphic screen must be able to implement high speed response of less than 1 second and the managed scale is more than 5,000Tag Point by applying industrial Micro-Processor of 32Bit or more. The designing that has emphasized on monitoring such as multi-window and intelligent alarm indicator, etc. must be implemented while enabling the monitoring and management of the screen by area. Also, each station must be built as global database and the Windows must be used for the operating system.

- **Programmable Logic Controller**

  It must have the controller function that has integrated measurement control and process control with CPU of 32 Bit or better. The remote control station performs loop control and sequence control while I/O Analog converter and Digital I/O Interface are attached inside the panel to have no separate conversion basis externally. Also, the remote control station must have the processing unit in which control operation part, network transmission part, CPU and memory card, etc. are built-in as well as the I/O unit with built-in I/O card, the signal conversion unit performing process I/O signal conversion, the insulator of digital I/O signal, the digital interface unit with built-in relay circuit and the built-in power supply.

### 5.3.2.6 Operator Workstation

**The Outline of Operator Workstation**

The Operator Workstation is a Man-Machine Interface device which becomes the window of operator and each device in order to monitor and control them and must be a state of art system to cope with high quality operation method required in the advanced information age, flexibility in connecting with other systems and having minimum number of operators. Also, the process operator station must be made simple as a window to communicate with plants and processes as well as having reliable promptness as the operator gets the grasp of the entire system. The process operator station requires providing quick and accurate information so that the operator does not make misjudgments and enabling operators to perform reliable operation as intended.

**Providing Signal Monitoring Function**

- **Real-time alarm generation and status value monitoring**
5. Electronical Specification

- Setup of importance by alarm point groups
- Output of alarm

Operation Record and Trend Management

- System data monitoring, setup of time periods
- Data analysis and report output

Real time status management of equipment/measuring instruments

Establishment of Operation Management System

- Facility maintenance
- Facility work operation management
- Facility material management

The Function of Process Operator Station

There must following function in the Process Operator Station.

- Monitoring and Control Functions
  
  An abundant screen must be prepared to monitor the overall process, must at least have the following monitoring and operation screen, must be prepared with adequate screen for future expansion and the indicator response or data modification time of the entire screen must be operated within 1 second. Also, each screen indicating processes as well as the screen indicating group and entire process must be prepared as display structure while also enabling screen division within the monitor. The process operator station of this disposal center must be equipped with the following screen.

- Overview Screen
  
  As the uppermost screen of Top-Down Operator, each unit plant name (unit group) of each disposal center must be indicated to be easily seen and must be able to simply grasp the operation status within the center in its entirety.

- Control Group Screen
  
  It must enable convenient operation by enabling compound indications such as loop, analog input and digital I/O sequence tag, etc. as well as the operation of plural loop at the same time with process operation screen which changes, manipulates and outputs the set value of each loop and control mode, detects loop status and performs digital I/O status indication and remote operation.
• Graphic Screen

As a screen which monitors and performs operating manipulations by graphic indication of plant and system, it must enable operators to make easy corrections using Graphic Package S/W. It must be able to unfold all screens that can be indicated such as overview, control group and tuning screen, etc. as one-touch screen and must be able to monitor the multiple loop status without the change of screen.

• Trend Screen

It indicates the process trend record point (tag, industrial unit, input value and range, etc.) on the coordinates, must be able to indicate even the data that has been collected during short period time by classifying them as historical trend (indicates past data) and real time trend (indicates current data), the data of given time must be found out by the operator using keyboard or mouse and must be able to store necessary data into FDD or stationary disk by units. The minimum requirements of trend are as follows.

Real Time Trend

- Trend Point : 250Point/OS or better
- Screen Indication Ability Score : 8Point/screen or better
- Trend Record Time : 4 hours or longer (optional)

Historical Trend

- Trend Point : 4000Point/OS or better
- Screen Indication Ability Score : 8Point/screen or better
- Trend Record Time : 1 day or longer (optional)

• Historical Message Screen

Historical message indicator must be able to record and print occurrence/recovery of various alarms, operation record and manipulations by operator, etc. on the system or process while the minimum requirements are as follows.

No. of stored events : 1,000Message/OS or better
No. of indicated events : Able to search the entire Message

Partial Examination Items
5. Electronical Specification

- Process Alarm
- Guidance Message
- Operation Record
- Operator manipulation
- Other

- Report Function
  Report is a function to print the process data of a plant as daily, monthly and yearly reports, must be able to indicate the recorded data on the screen with simple manipulation by operator as well as correct and reprint the data and must have the following functions.

  Sheet Types: Hourly report, daily report, monthly report, yearly report

  Data Types: Momentary value, average value, maximum value, minimum value, integrated value, operation value, etc.

- Process Database Builder Function for Process Management
  Must be able to gather and preserve momentary data.
  Must be able to gather and preserve historical data.
  Must have the integrated clock function.
  Must have the form (daily report, monthly report, yearly report) entry function.

- English Indicator Function
  The English indication must be made possible in group, tag service, name and alarm so that the operator can understand all information on the process easily and English output must be made possible even during report logging.

- System Malfunction Monitoring
  When the malfunctioning occurs to each element composing the system, the breakdown factors and details must be promptly indicated as multi window on the part of screen in a form of message with alarm and printed at the printer, indicated as color depending on the level of breakdown and must have the historical function of breakdown for efficient repairs.

- Safety Function
  By corresponding to the operation monitoring function to the scope of operator’s job
to enable classification as levels, it must be able to minimize mishandling.

- Engineering Function (Installed only at Process Engineering Station (PES))

  Load/Save Utility

  This must be able to save database such as the remote control station to stationary disks as well as load from the stationary disc generated from the builder to the remote control station.

System Management Function

  System Monitoring

  Database Modification Date Management

  Remote Diagnostics Support

System Utilities

System Generation Function

Process Operator Station Builder

  Preparation of Graphic Panel indicated on the Process Operation Station and generation of function

Remote Control Station Builder

  - Feedback control function, generates and changes sequence control function, etc.

Tag List Generation and Conversion Utility

Self-Documentation Function

  It must be able to print system configuration and functional requirements of stations generated at various builders.

**Hardware Requirements**

**Main Processor**

- **CPU** : Intel Xeon 2.8 GHz or over
- **Main Memory** : 2 GByte or over
- **Cache Memory** : 12 MB L3 or over
- **HDD** : 500 GByte or over
- **CD-ROM R/W** : DVD combo 16X or over
5. Electronical Specification

- Network : Ethernet 10/100 Base-T
- Graphic Card : 280x1024, 32 Bit color (128 MB Video Memory) or over
- Including chair and, accessory

Monitor

- Quantity : Refer to the drawing
- Size : Over 22 inch
- Resolution : Over 1920*1080
- Type : LCD Type

Software

- O.S : Windows XP Pro or 2000Pro or over
- Vaccine : V3 Internet Security 8.0 or over
- HMI : Common HMI S/W

Printer

- Type : Laser Jet Type
- Character : Korean, English, Special Character
- Paper : A4
- Resolution : 1,200 x 1,200 DPI
- Speed : 24 ppm
- Communication : Ethernet or Serial Communication

5.3.2.7 The Network of Monitoring Control Equipment

This system must use the local area network as a data communication function. Also, it must be able to cope with high speed transmission and broadband large scale of exclusive dual data-way connecting each device configuring the system. The self-diagnostics software is must be prepared at each station to minimize the influence of breakdown through prompt error detection and must select the international standard communication method to enable future expansions and connections with other models.
Switching HUB

24ea of 10/100BASE Port (TP Cable, RJ45 Socket)

Planning easily installable Plug and Play

Providing ideal traffic priority setting Function for huge network preforming real-time application program

Supporting Prior Que per Port

Display Power, Network Traffic, Dual mode, Link Status, Rate

Optic Switch

Standard : IEEE802.3
Topology : BUS
Control Method : CSMA/CD
Communication : Ethernet (TCP/IP)
Transmission Method : Over 10/100Mbps

Smart RING Composition

Power supply : DC 24V

5.3.2.8 Programmable Logic Controller (PLC)

Outline

The Programmable Logic Controller of monitoring control equipment is the local main control device, has built-in card or data highway control card, etc. with mounted CPU and memory, performs high speed operations, I/O processing, loop control of handled equipment and high speed sequence control, etc. and must be able to perform the monitoring control function flawlessly by connecting with operation station through data highway. This PLC performs feedback and sequence controls and must include the module for mutual connection and communication between I/O card and PLC with a station with built-in micro-processor which performs the input and output function of process signal. Each card can be easily inserted, withdrawn and exchanged even during operation and must not affect other cards even when there is abnormality of one card.
5. Electronical Specification

Programmable Logic Controller Panel List

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Panel Name</th>
<th>Particular of Items</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PLC-1</td>
<td>POWER HOUSE FOR MUVUMBA MULTIPURPOSE DAM</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>PLC-2</td>
<td>POWER HOUSE FOR MUVUMBA MULTIPURPOSE DAM</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>PLC-3</td>
<td>POWER HOUSE FOR MUVUMBA MULTIPURPOSE DAM</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>PLC-4</td>
<td>POWER HOUSE FOR MUVUMBA MULTIPURPOSE DAM</td>
<td>1</td>
</tr>
</tbody>
</table>

Programmable Logic Controller Function

The PLC must perform all functions given in this specification such as sequence, PID control, logical operation, ratio control, I/O and data transmission/reception as the one performing the key roles of this system such as control, communication and I/O functions, etc.

- Loop Control Function

At the station, various functions of PID adjustment for loop control, instruction and operation built-in internally while ratio control or program control, etc. must be enabled by combination of these things.

- Internal Gauge Function

There are adjustment and instruction functions while the station must have at least the following functions.

Adjustment Function

- PID Controller : PID, Feed Forward, deviated transfer, Variable Gain, other necessary functions for control
- Ratio Setter : The function of performing ratio operation toward input and outputting ratio setup value
- Program Setter : The function of outputting successive time functions in second, minute and step units as set value
- Analog Odometer : Adding function of Analog signals
- Pulse Odometer : Adding function of pulse signals
Indicator Function

· Indicator alarm instrument Detection of Analog signal Alarm (L, LL, H, HH)

· Operation Function : All operations and control functions necessary for plant control

  · Input Processing Section

The input processing section is for entire processing of signal revision to be inputted to the gauge and signal revision for linear, etc. while compensation PID control using dead time generation function as well as auto selector control using selector function, etc. are possible and must at least enable the following input processing.

High Selector : Compares 3 input signals, automatically outputs the input signal of higher side

Low Selector : Compares 3 input signals, automatically outputs the input signal of lower side

Limiter : Outputs the entry by restricting within the range of upper and lower set value

Liberalize : Outputs nonlinear input signals by making them into linear

Root Operation : Outputs by performing the root operation to the input signal

Common Operation : Executes operations that are peculiar to the plant

  · Sequence Control Function

The sequence control performs the processes in sequence according to predetermined sequence and conditions while the signal must be output according to each process.

Sequence Control Method

· It must be prepared using international standard languages such as FBD(Function Block Diagram) and Ladder method, etc. while the preparation, addition and modification, etc. must be simple even at on-line. The abnormality handling for each process must be simple when abnormalities occur by having program interlock function.

Sequence Parameter

· It must be able to allow set value of timer, set value of controller and output value, etc. while the sequence parameter must be able to use enough capacity.

Hardware Requirements

PLC shall be dualized with CPU, communication card, power supplier and etc. and constructed to remote monitoring and control. The specification is like below.
5. Electronical Specification

- **CPU (Central Processing Unit)**
  
  It shall have enough sequence process capabilities with embedded over 32bit Micro-Processor.

  - Program Control method: Embedded program repetitive operation
  - In/output control method: Batch processing method
  - In/output point: 512~2048 Point
  - Memory capacity: 512 kByte or over
  - Scanning Time: 50 msec.
  - Preserving memory while power-cut: Lithium battery for over 12months

- **Communication Unit**

  PLC shall have communication unit to connect HMI and other PLC.

  Communication unit shall be dualized.

- **In/output Module**

  Analog Input Module

  - Number of Input Point: over 16 Point per card
  - Input Signal: 4~20mA DC or 1~5V DC

  Analog Output Module

  - Number of Output Point: over 8 Point per card
  - Output Signal: 4~20mA DC or 1~5V DC

  Digital Input Module

  - Number of Input Point: over 32 Point per card
  - Input Signal: DRY contact point input

  Digital Output Module

  - Number of Output Point: over 32 Point per card
  - Output Signal: DRY contact point input

  Power Module

  Power module shall alarm and cut power from Voltage bus when sensing o&s of power and
Detailed Design for Muvumba Multipurpose Dam

have ground fault detection circuit.

Shall have self-diagnosis function including Power Check, CPU Check, Memory Function Check, I/O Response Check.

Shall have monitoring function including Event, Error Tracing, Data Tracing, Program Tracing.

Serial Interface RS-422 OR RS-485 2-Port or over

Software specification

Controlling function

It shall have PID control command, operation comparison command, FILE processing command, and communication command while process to performing Process control, data process and sequence control.

Programming language

It shall be programmable with Ladder diagram or Sequential Function Chart and have down loading function on HMI in operation center.

5.3.2.9 Internal Wiring

The internal wiring should correspond to related regulations and special wiring should be according to manufacturer standard.

5.3.3 Measuring Instruments

5.3.3.1 General Details

Local Detector

The spot where performance of detector, etc. can be sufficiently demonstrated as well as selecting the most ideal spot by going over the below items for the selection of installation spot while establishing the protection plan for places with danger of failure. Also, the builder must submit detailed blueprint and documents for above installation work and must perform supervision of other equipment if necessary.

Avoid high temperature, high humidity and select the place with little corrosive gas or dust.

The place with low vibration

While attaching and removing measuring instruments, enough space must be secured for easy maintenance inspections.

Should be installed indoors if possible.
5. Electronical Specification

Converter

The installation site of converter must be the dry place which is nearest to the detector and the local instrument board with built-in thunder arrester must be installed in case the installation site is outdoors for the protection against lightening.

Measuring Instrument List

<table>
<thead>
<tr>
<th>Category</th>
<th>Gauge No.</th>
<th>Measured Item</th>
<th>Quantity</th>
<th>Gauge Type</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power House</td>
<td>LS-101</td>
<td>Water level of pit</td>
<td>1unit</td>
<td>Quick float type</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>WLM-2, 3</td>
<td>Water level of water canal</td>
<td>2units</td>
<td>Ultrasonic wave type</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>FLM-1, 2</td>
<td>Flow rate of irrigation ditch</td>
<td>2unit</td>
<td>Electronic type</td>
<td>1,000A</td>
</tr>
<tr>
<td>DAM</td>
<td>WLM-1</td>
<td>Water level of dam</td>
<td>1unit</td>
<td>Ultrasonic wave type</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>WLM-4</td>
<td>Water level of M-8 dam</td>
<td>1unit</td>
<td>Ultrasonic wave type</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>RGM-1</td>
<td>Water level of dam</td>
<td>1unit</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

5.3.3.2 Electronic Flow Meter

Perpendicular Section of Electronic Flow Meter

In case there are 90° bend, T, extension pipe or unfold stop valve at the upper part of detector, the length of perpendicular section should be 5D or more from the center of detector and may be changed to the perpendicular section presented by manufacturer depending on field conditions.

At the bottom section of the detector, the perpendicular of 2D or more must be secured from the center of detector and must take precautions for the following items.

- In case of attaching the butterfly valve, the moving body of the valve must be prevented from going into the tube of the detector.
- In case of directly connecting the detector and valve, etc., there are cases in which the bolts cannot be inserted and in this case, use the ball screw to combine them.

Piping Precautions

- It must be the pipe structure filling (full tube) the fluid within flux detector.
The halt of fluid must be possible at the state of filling the fluid within the detector using the valve.

It is ideal to install at the lower section of the detector in case there is one valve.

In case of installing the detector vertically, the flow of water must be from bottom to top to satisfy a and b above.

Wiring Precautions

- The wiring between detector and converter must be wire tube distribution.
- The lid of detector terminal box must never be opened.
- The waterproofing of terminal must be performed completely for wiring.
- Because the signal circuit of high impedance is vulnerable to noise, the signal circuit and exciting circuit must be away from each other so that they wouldn't be crossed from extra cable.

Detector and Converter

Sensor

- Model name         : Magflux Sensor
- Type          : Flange
- Measuring range  : 0 ~ 10 m/s
- Temperature     : -10℃ ~ 60℃
- Material         : Hard rubber (Lining), Carbon steel(Flange), SUS316L, Hastelloy B.C & Titanium (Electrode)
- Enclosure   : IP68
- Accuracy  : ±0.25%
- Cleaning   : Automatic electrode cleaning

Converter

- Model name  : Magflux Converter
- Display       : Backlight Graphic LCD Display
- Fluid condition : min conductivity 5μS
- Accuracy : ±0.25%
5. Electronical Specification

- **Output**: D.C 4~20mA, 2 relays
- **Temperature**: -20~60°C
- **Enclosure**: IP67
- **Material**: Polycarbonate, Reinforced-glass
- **Memory**: 256Kb (20,000 data)
- **Power supply**: 230/115V AC, 50/60Hz
- **Function**: Automatic electrode cleaning, Re/Forward flow, Data graph display, Max 4 sensor expendable, pipe cut-off check.

### 5.3.3.3 Ultrasonic Level Meter

**Converter Installation**

It must be installed at places without vibration and of easy maintenance.

The places with temperature change must be avoided.

The places affected by direct sunlight or rainy wind must be avoided, and the shelter must be equipped for unavoidable cases.

**Installation of Detecting Section**

The stability while measuring reception wave is secured by setting insensible area of 0.3m or more.

Installed at the place without obstacles at the gap until the measuring section.

The places with lot of bubbles and residues with high sticking ability should be avoided.

**Wiring Precautions**

Wire is distributed by separating with noise sources such as motor power source in order to prevent noise.

The terminal case interior should be waterproof structure and must establish a penetration proof plan of rainwater using wire tube, etc. at the electrical wiring hole so that the rainwater doesn't get in through electrical wiring hole during installations.
Detailed Design for Muvumba Multipurpose Dam

Detector and Converter

Sensor

- Model name: Shuttle Level Sensor
- Type: Ultrasonic side vibration by pulse reflection
- Measuring range: 0~15m
- Shooting angle: 3°
- Frequency: 30kHz
- Shooting method: Shooter side vibrate
- Cover: 45° (Signal concentration, prevent outer effect)
- Material: Cover-Polypropylene, Shooter-Crystal, Surface-POM
- Enclosure: IP68 (10m water-proof)
- Accuracy: within ±0.2% (within ±1mm)
- Temperature: -20℃~+60℃
- Structure: Build-in Temperature sensor (Temperature compensation)

Converter

- Model name: Shuttle Level transmitter
- Display: LCD (4-digit, 10 symbols)
- Resolution: 1mm
- Enclosure: IP65
- Signal Process: DSP
- Output: 4~20mA (Bar Graph display)
- Temperature: -20℃~+60℃, 95% Rh
- Power supply: AC 110 or 220V, 10 ~ 30V DC
- Function: Learning function (automatic zero point, Evading Obstacle), Signal adjustment (No Fume, Pump effect), Shooting angle concentration (Steam, dirt effect)
5.3.3.4 Quick-Float Type Level Switch

- Type: Quick- Float Type
- Max. Temperature: 20°C
- Enclosure: IP65
- Range: 0~6M
- Operating Temperature: 0°C~+60°C

5.3.3.5 Rainfall Meter

- Power Supply: DC 15 ~ 35V
- Accuracy: ±1%
- Operating Temperature: 0°C~+50°C
- Maximum flow: 1,600mm
- Minimum flow: 2mm
- Enclosure: IP65
- Output: DC 4~20mA

5.3.4 Uninterruptible Power Supply

5.3.4.1 Ratings

PWM inverter type UPS shall be applied to main computer facility and RCS.

Scope of supply

UPS Module: 1 set
- Rectifier and Charger
- Inverter (PWM Control)
- Electronic Bypass (Static Bypass Switch)

Battery PNL.(Including Battery): 1 set
**Surrounding**

- Location: Water purification plant
- Altitude: Max. 1000m

**Operation temperature**

- UPS: 0°C ~ 40°C
- Battery: 20°C ~ 25°C (ideal)
- Storage temperature: -15°C ~ +50°C
- Battery storage period without charging (at normal temperature): Max. 6months
- Relative humidity: Max. 95%

**Battery**

- Power-cut compensation time: over 30 minutes
- Type: Long life-time, no maintenance, enclosed type battery
- Installation: Inside steel panel

**5.3.4.2 Operation Outline**

**Normal Operation**

The rectifier supplies D/C to inverter by receiving common power and inverter supplies current power supply of good quality to the load and recharging devices composed of separate circuit must be able to recharge the storage battery automatically.

**Blackout Operation**

When the common power supply gets stopped, the inverter must supply the stable current voltage to the load for the duration of discharge time assigned by storage battery power as the switch of storage battery gets connected.

**Normally Restored Operation**

When the intercepted common power gets supplied once again, the inverter restores to normal operation status by getting supplied with direct power supply from the rectifier, the storage battery switch is cut off at this time and the recharging device must recharge the storage battery up to regulated voltage.
5. Electronical Specification

Bypass Switch (Synchronizing Switch)

During sudden breakdown or load short circuit of inverter, the power that had been supplied to the load must be supplied by being randomly switched using synchronizing switch with separately composed bypass power source.

5.3.4.3 Structure and Function

Rectifier

The rectifier is commutation circuit composed of semiconductor converts A/C to D/C and must be equipped with even circuit to level the rectified pulsating waves.

Recharging Device

The recharging device must be able to recharge the storage battery to an optimum state by converting A/C power as direct constant voltage to create the maximum discharge efficiency by maintaining ordinary storage battery as immobile recharging state.

Inverter

The inverter converting A/C to D/C must produce high efficiency and low noise electricity converter by composing as Sine PWM method of high frequency switching type composed of IGBT.

Output Transformer

The output transformer insulates the first coil connected to inverter and second coil connected to output section while being able to convert inverter output voltage as necessary optimum voltage.

Synchronizing Switch

The synchronizing switch must be produced as the method of randomly switching the load to by-pass power source section during inverter breakdown and overloading.

Display Operation Panel

In order to make the operation and identification of equipment simple, the following operation panel equipped with control devices, status indicators and alarm devices should be prepared to easily grasp the operation status by placing LED on the mimic diagram.

Measuring Functions

The following measurement factors must be digitally indicated on the display board.
Detailed Design for Muvumba Multipurpose Dam

- A/C input voltage
- A/C input current
- A/C input frequency
- Storage battery voltage
- A/C output voltage
- A/C output current
- A/C output frequency

Alarm and Status Indication

The following alarm and status indication must be enabled using LED lamp on the operation system map.

- Input power constant
- Inverter operation
- By Pass operation
- Output constant
- Recharge and discharge of battery
- Other alarms

Control Devices

- The following control devices must be installed at the operation board.

- System maneuver
- System halt
- Alarm halt
- Lamp test

5.3.4.4 Structure

The operation board must use LED (Light Emitting Diode) for all status indicators to guarantee long life span by attaching it at the upper front section to make equipment operation simple.

The panel is indoor enclosed, uses sheet steel of door-2.0mm or more, other 1.5mm or more
and must install fan as well as heater for air ventilation and temperature compensation.

The terminal of main power source must use copper stick that can adequately endure consumed capacity and has good conduction ratio as well as using "H" type or better for insulation material of main power transformer systems.

The wiring should use 380V vinyl insulation wire for electrical equipment or better while terminal section of all main control wires must be attached firmly using terminal.

**5.3.5 CCTV Installation**

**5.3.5.1 Equipment Outline**

This equipment must be the one that can monitor the operation status of main equipment and entire disposal center using monitor at the entire central control room by installing monitoring camera at the machine room and outdoors.

**5.3.5.2 Equipment Outline**

**Local Equipment**

It must be a reliable monitoring system that can replace human eye using the monitoring camera.

The electronic tube of camera must be semi-permanent and must not require additional maintenance using CCD type in which the image is shown on the monitor without preheating when the power has been supplied.

The electric zoom lenses are attached to the camera to enlarge and monitor distant objects and must be able to move the camera in all directions using rotator.

The housing of camera is Weather Proof type and must be produced to not get influenced by natural conditions such as salinity, snow, rain, dust wind and corrosive gas.

The receiver must perform functions such as Lens Control and Light power On/Off, etc. of corresponding camera by analyzing the motion data signal received from the Digital Video Recorder (DVR).

**Digital Video Recorder (DVR)**

The CCTV applied to this disposal center must be able to convert analog video signals of camera into digital type to be stored into HDD and observed at the monitor.

The system operation must be simple and the operator must be able to use the program depending on necessity as a device to select and control monitoring camera.
The digital video recorder must have simple composition, and wiring and installation of the recorder should be easy while the expansion of system must be also simple.

It must be able to monitor the entire image by optional selection at the central control room and all controls must be performed simply.

5.3.6 Spare Parts and Tools

5.3.6.1 Spare Parts

The builder must supply the following spare parts and tools for equipment operation, maintenance and repairs.

- CPU Module : 2EA
- Ethernet Communication Card : 1EA
- Serial Communication Card : 2EA
- Power Supply : 3EA
- DI Card : 3EA
- DO Card : 2EA
- AI Card : 2EA
- AO Card : 1EA
- Arrester (Power) : 4 sets

5.3.6.2 Maintenance Tools

- Pliers (6", 7", 8") : 1EA each
- Nipper (6", 7") : 1EA each
- Long Nose Pliers (6", 8") : 1EA each
- Screw Driver (6x10", 8x6") : 1EA each
- Changeable Screw Driver : 1 set
- Electric Drill (6mm, 13mm) : 1EA each
- Applicator (2~14㎟) : 1 set
- Electric Soldering Iron : 1EA
5. Electronical Specification

- Portable Searchlight : 1EA
- MULTI-TESTER : 1EA
- Electroscope : 1EA
- Insulation-Resistance Tester (500V 1000MΩ, 1000V 1000MΩ) : 1EA
6. Architectural Specification

6.1 General

6.1.1 Scope

This specification is based on standard architectural specifications unless specified otherwise, and is applied to the construction of the Muvumba Multipurpose Dam Project.

6.2 Applied Standards

It is given that the following standards are applied in this specification within the indicated scope.

6.2.1 Standards

(1) EN 100820:2005 Concrete Reinforcing steel, Welding steel: General
(2) EN 12350-1:2000 Concrete Tests – Phase 1. Sampling
(3) EN 12350-2:2000 Concrete Tests – Phase 2. Slump Testing
(5) EN 12390-1:2000 Hardened Concrete Tests – Phase 1. Shape, Size, Sample & Other Molding Requirements
(6) EN 12390-2:2000 Hardened Concrete Tests – Phase 2. Hardening of Sample for Assembly & Strength Test
(7) EN 12390-3:2000 Hardened Concrete Tests – Phase 3. Compressive Strength Sample Test
(9) EN 12504:2000 Structural Concrete Test
(10) EN 12620:2002 Concrete Aggregates
(11) EN 13139:2002 Mortar Aggregates
(12) EN 13791:2007 Compressive Strength Evaluation of Cast-In-Place Concrete for Structural/Prefabricated Concrete
6.3 Submissions

6.3.1 Submission & Approval

Contractor shall commence the construction only after shop drawings have been submitted to and approved by the project manager in order to confirm the compliance with the contract and the design documents, and to prevent execution errors and omissions. The approved shop drawings then shall be submitted in accordance with the “Submissions & Project Administration Documents”.

6.3.2 Preparation

Shop drawings shall be prepared in compliance with the requirements of the design documents and clearly state the materials and construction/installation/finished statuses with accurate indication of sizes and scales. Any adjustments made to comply with the design documents also must be specified.
6.3.3 Contents

Shop drawings shall include contents specified in each clause. The following shop drawings shall be prepared (the followings represent major works only; refer to the corresponding clause for the items not listed below)

1. Plan & shop drawings for temporary construction
2. Shop drawings for foundation excavation & soil retaining works
3. Detailed installation drawings for forms & floor posts
4. Shop drawings for rebar assembly & joint
5. Concrete placement plan
6. Brickworks drawings
7. Course drawings for tiles & stone masonry
8. Detailed ceiling drawings (including ceiling frame works) - Fire protection, lighting, facilities
9. Shop Drawings for various mechanical facilities (sanitary, air conditioning/heating, ventilation, fire protection, etc.)
10. Shop drawings for various waterproofing works (including plastering works)
11. Shop drawings for various window works (wooden, aluminium, steel, stainless, plastic, etc.)
12. Shop drawings for expansion joints of roofs (including roofing materials)
13. Shop drawings for insulation works
14. Shop drawings for various interior finishing works
15. Detailed installation drawings for various metallic works
16. And other shop drawings requested by the project manager
17. Sign installation works

6.3.4 Allowable Omissions & Required Photographs

1. Submission of documents and samples for materials that are included in multiple specifications and have been approved of their identical samples previously can be omitted.
2. Photographs required for submissions are specified in “Appendix 1”.

6.4 Materials Sampling & Testing

6.4.1 Submission & Storage

Contractor shall submit samples of materials that satisfy the requirements specified in the design documents to the project manager for approval. The submitted samples shall be stored either in the owner’s or contractor’s office until the construction is completed.

6.4.2 Submission of Samples

The samples that shall be submitted in each phase of the works are specified in each clause. The followings are some of the samples to be submitted (the followings represent major works only; refer to the corresponding clause for the items not listed below).

1. Rebar (per each size)
2. Plaster sand
3. Wire mesh, materials separator, material separator, metal lath, various non-slips
4. Cement bricks
5. Water repellent materials
6. Waterproofing liquid
7. Expansion joint materials for roofs
8. Tiles, stones (floors, walls)
9. Sheet waterproof materials, asphalt-related products (shingle products)
10. Epoxy floor materials (for construction)
11. Various window materials (downsized complete products) - Steel, aluminium, plastic
12. Stainless doorframe bars
13. Complete wooden/steel flat stainless door flames cut in 45° (coated and downsized complete products with accessories attached)
14. Stainless shutters (rings and slat bars)
15. Various sealing and calking materials
16. Stainless spandrel and molding materials
17. Steel grating
18. Various stainless pipes for each purpose and size (ready-welded stairway handrails, ladders,
et al.

(19) F.R.P
(20) Roof drains, linear gutters
(21) Various mechanical facility materials (sanitation, air conditioning/heating, ventilation, etc.)
(22) All window-related steel materials: door locks, door checks, floor hinges, pivot hinges, hinges, handle brass cat bars, brass rails, rollers
(23) Various glasses (per each purpose, size, type)
(24) Various coating materials (water, oil, ceramic, bon tile, in-coating, texture coating)
(25) All lightweight steel frame ceiling casting materials
(26) All ceiling finishing materials
(27) All floor materials
(28) And other materials requested by the project manager

6.4.3 Inclusions
(1) Material samples (limited only to the materials specified in each clause)
(2) Serial numbers and quality standards
(3) Lead time
(4) And other items specified in each clause

6.4.4 Time & Quantity of Submission
One set of samples shall be submitted 15 days prior to installation or application of the materials. However, extra period shall be considered for the materials that require testing or inspection as specified in the clauses.

6.4.5 Testing
Contractor shall conduct testing of sample materials as instructed by the project manager prior to the actual works in order to be approved of their suitability.
(1) Decoration laying of cement bricks
(2) Cement mortal plastering
(3) Tiling

(4) Asphalt sheet waterproofing, polyurethane waterproofing, seepage waterproofing, cement liquid waterproofing, calking works

(5) Metal handrails and metal ladders

(6) Steel/aluminum window installation

(7) All coatings (water paint, bon tiles, in-coat, texture coat, oil paint for iron axes)

(8) Asphalt shingle

(9) Linear gutters

(10) And other tests designated by the project manager

6.5 Quality Management

6.5.1 Quality Test Standards

(1) Quality test standards are specified in “Appendix 2”.

(2) BS or EN shall be applied if quality test standards are not specified in the clauses.

(3) A specimen shall represent the collective quality unless otherwise specified.

(4) These standards are not applied to consigned materials.

(5) Materials or items that cannot be tested by quality testing specialists may be tested in the presence of the project manager.

(6) Major materials (e.g. rebar, concrete, bricks, tiles, etc.) shall still be tested accordingly to “Appendix 2”, even if their qualities have been accepted by BS, EN or other relevant regulations.

6.5.2 Magnitude of Test Lab & Assignment of Testing Personnel

(1) Magnitude of test lab & assignment of testing personnel
6. Architectural Specification

a. Magnitude of test lab

<table>
<thead>
<tr>
<th>Classification</th>
<th>Magnitude of Construction</th>
<th>Test Lab Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-scale quality management</td>
<td>A total construction cost higher than 500 trillion KRW (incl. consigned material costs)</td>
<td>Larger than 100 m²</td>
</tr>
<tr>
<td></td>
<td>A building with more than 16 stories with a total floor area larger than 30,000 m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A construction that establishes a quality assurance plan</td>
<td></td>
</tr>
<tr>
<td>Midscale quality management</td>
<td>A total construction cost higher than 100 trillion KRW (incl. consigned material costs)</td>
<td>Larger than 50 m²</td>
</tr>
<tr>
<td></td>
<td>A multiplex building with a total gross area larger than 5,000 m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A construction that does not require a large-scale quality management</td>
<td></td>
</tr>
<tr>
<td>Small-scale quality management</td>
<td>A total construction cost higher than 2 trillion KRW</td>
<td>As agreed</td>
</tr>
<tr>
<td></td>
<td>A total gross area larger than 660 m²</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A construction that does not require a midscale quality management</td>
<td></td>
</tr>
</tbody>
</table>

b. Assignment of testing personnel

① Assigning criteria

<table>
<thead>
<tr>
<th>Classification</th>
<th>Testing Personnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large-scale quality management</td>
<td>1. More than one specialist or senior quality manager</td>
</tr>
<tr>
<td></td>
<td>2. More than one junior quality manager</td>
</tr>
<tr>
<td></td>
<td>3. More than one intermediate quality manager</td>
</tr>
<tr>
<td>Midscale quality management</td>
<td>1. More than one junior quality manager</td>
</tr>
<tr>
<td></td>
<td>2. More than one junior or intermediate quality manager</td>
</tr>
<tr>
<td>Small-scale quality management</td>
<td>1. More than one junior quality manager</td>
</tr>
</tbody>
</table>

② Qualification

Qualifications required for testing personnel are specified in “Appendix 3”.

③ Testing personnel taking charge of quality management

If a quality manager is quantified to be in charge of quality management, he/she may take the role rather than assigning another person.
6.5.3 Testing Equipment

(1) Testing equipment shall be provided as specified in “Appendix 4”.

(2) Equipment that require calibration such as compressive strength measurer, scale, micro meta moisture content measurer shall be calibrated at least once a year by a specialist authorized by the government.

6.5.4 Construction Confirmation

The scope, time, and major items for construction confirmation works are specified in “Appendix 5”.

6.5.5 Works & Times for Field Inspections

Field inspections shall be performed on the following basis:

<table>
<thead>
<tr>
<th>Work</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Civil works</td>
<td>After completion of foundation excavation</td>
</tr>
<tr>
<td>2. Pile foundation</td>
<td>After completion of main piling</td>
</tr>
<tr>
<td>3. Reinforcement concrete</td>
<td>After completion of concrete placement</td>
</tr>
<tr>
<td></td>
<td>After completion of various rebar placements</td>
</tr>
<tr>
<td>4. Masonry works</td>
<td>After completion of the substructure of the 1st floor</td>
</tr>
<tr>
<td>5. Waterproofing works</td>
<td>Immediately before interior waterproofing</td>
</tr>
<tr>
<td></td>
<td>Immediately before exterior waterproofing</td>
</tr>
<tr>
<td>6. Cement mortal &amp; floor finishing</td>
<td>Immediately before mortar plastering</td>
</tr>
<tr>
<td>7. Terrazzo &amp; artificial stones</td>
<td>Immediately before laying terrazzo &amp; artificial stones</td>
</tr>
<tr>
<td>8. Tiling</td>
<td>Immediately before tiling</td>
</tr>
<tr>
<td>9. Windows</td>
<td>Immediately before window installation</td>
</tr>
<tr>
<td>10. Glasses</td>
<td>Immediately before glass work</td>
</tr>
<tr>
<td>11. Coating</td>
<td>Immediately before coating</td>
</tr>
<tr>
<td>12. Decoration</td>
<td>Immediately before decoration</td>
</tr>
<tr>
<td>13. Others</td>
<td>15-30 days prior to the completion</td>
</tr>
</tbody>
</table>

6.5.6 Test Construction

(1) A test construction is a part of the main construction and shall be performed at the designated location with approved method and materials in the presence of the project manager.

(2) A test construction shall be performed and approved at an initial stage of the work, and its
quality will be the standard for the work once approved.

6.6 Prior Consultations

The followings shall be consulted with the project manager prior to execution.

(1) Sequences and methods of works
(2) Manpower and equipment
(3) Temporary buildings and utilization of the lands
(4) Sections where pipes are buried and slabs/beams penetrate for mechanical, electrical, and communication works
(5) And other matters that are considered required

6.7 Common Terminology

Mix ratio between cement and sand for cement mortar refers to volume mix ratio unless otherwise specified.

6.8 Administration Documentation

6.8.1 Relative Clause

The clause details “Document Submission and Administration Documentation”.

6.8.2 Relevant Regulations

The contractor shall actively cooperate in provision of required documentation works in order to acquire permits under the Town Planning and Zoning Act, Building Act, Telecommunications Act, Sewage Act, High-Pressure Gas Safety Act, Fire Services Act, etc.

6.8.3 Modification & Improvement

Detailed description of the design shall be provided to the relevant authority if required for permit acquisition. Any inadequacies discovered during the process shall be immediately modified and improved.
6.8.4 Required Permits

(1) Temporary buildings
(2) Commencement of construction
(3) Building authorization requests and inspections
(4) Septic tanks
(5) Commencement and completion of fire protection works
(6) And other permits required by the regulations

6.8.5 Provision & Submission of Documents

The contractor shall prepare required documents based on the facts and proofs, and place them to be conveniently viewed by the project manager. The documents shall be submitted on time in designated quantity.

6.9 Submission of Completion Documents

The following documents shall be submitted for completion:

(1) Certificate of pre-test application from, and general building management log
(2) Certificate of fire protection completion tests
(3) Certificate of electric safely tests and telecommunication facility completion tests
(4) Certificate of septic tank completion tests
(5) Authorization of hazardous material installation and certificate of completion tests (fire department)
(6) Confirmation of flood protection installation
(7) Quality confirmation documents for insulating and major materials
(8) Certificate of boiler installation tests
(9) Certificate of high-pressure gas completion tests
(10) Safety certificates of various hoists (before/after installation of hoists larger than 3ton)
(11) And other documents required by relevant regulations
All the costs as well as taxes and the public utilities’ charge required for the permit acquisitions are included in the main construction.

### Appendix 1. Required Photographs

<table>
<thead>
<tr>
<th>Work</th>
<th>Photographs</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Temp const.</td>
<td>Temp storage, offices, test lab, temp fences</td>
<td>Refer to BOQ</td>
</tr>
<tr>
<td>2. Civil works</td>
<td>Foundation status after excavation</td>
<td>Complete view and major parts for evaluation of bearing capacity</td>
</tr>
<tr>
<td>3. Reinforced concrete</td>
<td>Statuses of reinforced concrete placed in foundation, slabs, beams, pillars, retaining walls and openings</td>
<td>Placement spacing, coating thicknesses, development &amp; splice lengths, cleanness</td>
</tr>
<tr>
<td></td>
<td>Rack fillers, struts</td>
<td>Spacing of fillers and struts</td>
</tr>
<tr>
<td></td>
<td>Concrete curing</td>
<td>Placement and status of lagging cover</td>
</tr>
<tr>
<td></td>
<td>After removal of foundation form</td>
<td>In accordance with the standards</td>
</tr>
<tr>
<td>4. Masonry works</td>
<td>Status of mortar</td>
<td>Around doorframe, bottom of slab, bottom of lintel, inside of AD/PD, around pipes</td>
</tr>
<tr>
<td>5. Waterproofing works</td>
<td>Waterproof projection</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water-filling test</td>
<td>Restroom, utility room, rooftop of flat roof</td>
</tr>
<tr>
<td></td>
<td>Before placing press concrete on rooftop</td>
<td>Installation status of foam polystyrene lags, expansion joints, etc.</td>
</tr>
<tr>
<td>6. Insulation works</td>
<td>Installation of insulators</td>
<td>Including easily gapped locations (around window frames, etc.)</td>
</tr>
<tr>
<td>7. Others</td>
<td>Filed tests</td>
<td>Slump, specimen production, compressive strength, washing analysis, air content, etc.</td>
</tr>
<tr>
<td></td>
<td>Walls of buildings adjacent to the site</td>
<td>To be clearly dated</td>
</tr>
<tr>
<td></td>
<td>Design modifications</td>
<td>Cracks shall be photographed if present</td>
</tr>
<tr>
<td></td>
<td>Complete views</td>
<td>Monthly progression or immediately after completion of major works</td>
</tr>
</tbody>
</table>

Note) Photographed locations may be designated by the project manager as necessary
## Appendix 2. Quality Test Standards

(1) The followings are “Quality Test Standards” for materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Item</th>
<th>Method</th>
<th>Frequency</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement (Class 1, ordinary portland cement)</td>
<td>As specified in the relevant clause</td>
<td>BS EN</td>
<td>1. 3 months after the manufactured date 2. When the quality seems to have been changed 3. Per every 300 ton</td>
<td>Sack: 1 Bulk: 5kg</td>
<td></td>
</tr>
<tr>
<td>White Portland cement</td>
<td>As specified in the relevant clause</td>
<td>BS EN</td>
<td>1. Per each manufacturer and every 100 ton 2. Per every 500 welded joints</td>
<td>Samples to be indicated in “Remark”</td>
<td></td>
</tr>
<tr>
<td>Rebar</td>
<td>As specified in the relevant clause</td>
<td>BS EN</td>
<td>1. Per each manufacturer and every 100 ton 2. Per every 500 welded joints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete chemical admixtures</td>
<td>As specified in the relevant clause</td>
<td>BS EN</td>
<td>1. Per each manufacturer 2. When the quality seems to have been changed after 3 months of storage</td>
<td>Freeze-thaw test Length change test: if necessary</td>
<td></td>
</tr>
<tr>
<td>Infrared absorption spectrums</td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregates (incl. crushed aggregates)</td>
<td>Specific gravity, absorption rate</td>
<td>BS EN</td>
<td>1. Per each aggregate source 2. Per every 1,000 m²</td>
<td>1. Field test: Specific gravity, absorption rate, filtering passage through 0.08 mm net, chloride contents 2. Additionally for precast concrete: Prior to initial fabrication and welding and once a month during fabrication period</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Passage through 0.08mm net</td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Organic impurities of sand</td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abrasion (thick aggregates)</td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Safety</td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Filtering</td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surface moisture</td>
<td>BS EN</td>
<td>More than once a day</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chloride contents (using salinity meter)</td>
<td>BS EN</td>
<td>More than 3 times a day per each manufacturer (for sea sand)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unit weight</td>
<td>BS EN</td>
<td>1. Per each aggregate source 2. Per each quality change</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 6. Architectural Specification

<table>
<thead>
<tr>
<th>Material</th>
<th>Item</th>
<th>Method</th>
<th>Frequency</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregates (incl. crushed aggregates)</td>
<td>Potential alkali reactivity of aggregates</td>
<td>BS EN</td>
<td>1. Per each aggregate source 2. Per each quality change</td>
<td>1 set x 3</td>
<td>1. Submission of test results 2. Reconfirmation with mortar bar or rapid method if results from the chemical test prove to be hazardous</td>
</tr>
<tr>
<td>Concrete water</td>
<td></td>
<td>BS EN</td>
<td>Per each water intake except for drinking water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td>Compressive strength (specimen)</td>
<td>BS EN</td>
<td>Per each foundation, layer, and other placing locations</td>
<td>Strength for 7 days: 1 set x 3 Strength for 28 days: 3 sets x 9</td>
<td>1. Once per each 150m³ unless specified otherwise 2. Field test=</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Per each layer</td>
<td>For form removal: 1 set x 3</td>
<td></td>
</tr>
<tr>
<td>Slump</td>
<td></td>
<td>BS EN</td>
<td>1. Per each different mixture 2. Per every 150m³ (50m³ for flowing concrete)</td>
<td></td>
<td>1. Executed at placing location 2. Field test</td>
</tr>
<tr>
<td>Air content</td>
<td></td>
<td>BS EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Washing analysis</td>
<td></td>
<td>BS EN</td>
<td>When the quality seems to have been changed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chloride contents</td>
<td></td>
<td>BS EN</td>
<td>Per every 150m³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Modified in-situ mix</td>
<td></td>
<td>BS EN</td>
<td>Once before commencing the work</td>
<td></td>
<td>If B/P is installed</td>
</tr>
<tr>
<td>Concrete bricks</td>
<td>As specified in “Concrete Brick Works”</td>
<td>BS EN</td>
<td>Per every 30,000 bricks</td>
<td>1 set x 6 bricks</td>
<td>1. Field test 2. Add 7 bricks per a set if no standard deviation is available</td>
</tr>
<tr>
<td>Red bricks</td>
<td>Dimension, compressive strength, absorption ratio</td>
<td>BS EN</td>
<td>Per every 20,000 bricks</td>
<td>1 set x 10 bricks</td>
<td>Field test</td>
</tr>
<tr>
<td>High-density protective polyethylene for waterproofing layer</td>
<td>As specified in “Asphalt Waterproofing”</td>
<td></td>
<td>Once per each tool</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cement liquid waterproof agent</td>
<td>As specified in “Asphalt Waterproofing”</td>
<td>BS EN</td>
<td>Per each manufacturer and product</td>
<td>1 set x 1ℓ</td>
<td></td>
</tr>
<tr>
<td>Internal sealing material</td>
<td>Mold-resistant</td>
<td>BS EN</td>
<td>Per each tool</td>
<td>1 set x 300 ml</td>
<td></td>
</tr>
<tr>
<td>Material</td>
<td>Item</td>
<td>Method</td>
<td>Frequency</td>
<td>Qty</td>
<td>Remark</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------</td>
<td>--------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>ceiling molding, material separators, washboards, curtain boxes (for wooden materials)</td>
<td>Moisture content</td>
<td>BS EN</td>
<td>Once per each tool</td>
<td>3</td>
<td>Field test</td>
</tr>
<tr>
<td>Plywoods</td>
<td>Moisture content</td>
<td>BS EN</td>
<td>Once per each tool</td>
<td>3</td>
<td>Field test</td>
</tr>
<tr>
<td>Wooden materials</td>
<td>Moisture content</td>
<td>BS EN</td>
<td>Per every 1m² immediately before use</td>
<td></td>
<td>Field test</td>
</tr>
<tr>
<td>Foam polystyrene thermal insulation materials (extruding method)</td>
<td>As specified in the relevant clause</td>
<td>BS EN</td>
<td>1. Per every 1,000m³ constructed area 2. Per every 1,000 materials</td>
<td>1 set x 4</td>
<td>1. Field test: combustibility 2. No compressive strength test for 9mm thickness</td>
</tr>
<tr>
<td>Foam polystyrene thermal insulation materials (bead method)</td>
<td></td>
<td>BS EN</td>
<td></td>
<td></td>
<td>Field test: density</td>
</tr>
<tr>
<td>Planar thermal insulators</td>
<td>Thickness, density, bending failure, water absorption rate, thermal conductivity, flame retardancy</td>
<td>BS EN</td>
<td>Per every 1,000m³</td>
<td>200×150mm: 5 300×300mm: 1</td>
<td>Field test: thickness, density</td>
</tr>
<tr>
<td>Glass wool boards</td>
<td>As specified in KSL 9102</td>
<td>BS EN</td>
<td>1. Per every 1,000m³ constructed area 2. Per every 1,000 materials</td>
<td>300×300mm: 1</td>
<td>Field test: density</td>
</tr>
<tr>
<td>Korean rooftop</td>
<td>Bending, absorption, freeze &amp; burst</td>
<td>BS EN</td>
<td>Per every 1,000 materials</td>
<td>1 set x 6</td>
<td></td>
</tr>
<tr>
<td>Asphalt shingle</td>
<td>Unit weight of the product</td>
<td>BS EN</td>
<td>Once per each tool</td>
<td>1 set x 3</td>
<td>Field test: unit weight of the product</td>
</tr>
<tr>
<td>Wooden window &amp; frame materials</td>
<td>Dimension, moisture content</td>
<td>BS EN</td>
<td>Per every 500 materials</td>
<td>1 set x 15</td>
<td>Field test</td>
</tr>
<tr>
<td>Synthetic resin widow &amp; frame materials</td>
<td>Dimension</td>
<td>BS EN</td>
<td>Per every 500 materials</td>
<td>1 set x 5</td>
<td>Field test</td>
</tr>
<tr>
<td>Steel window &amp; frame materials</td>
<td>Dimension</td>
<td>BS EN</td>
<td>Per every 500 products</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Fire door</td>
<td>As specified in the relevant clause and regulation</td>
<td>BS EN</td>
<td>Per every 500 products</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### 6. Architectural Specification

<table>
<thead>
<tr>
<th>Material</th>
<th>Item</th>
<th>Method</th>
<th>Frequency</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
</table>
| Aluminum window & frame       | Tensile strength, dimension   | Per every 500 materials                                                | 3                          |     | Tension test; SEA
- Thinner than ψ20: No. 5 specimen
- Thicker than ψ20: No. 4 specimen
- If No. 485 are unavailable: No. 13B specimen
- If No. 485 & 13 are unavailable: Test with a maximum possible section or initially extruded section |
<p>| Cylindrical door locks        | Consecutive opening/closing test, distortion, tension/vertical load test | Per each manufacturer                                                  |                            |     | Door lock: attached to approx. &amp;m thickness testing board or door x 3  |
| Box type door locks           | Consecutive opening/closing test, consecutive opening/closing test of dead bolt, tension/vertical load test of handle | Per each manufacturer                                                  |                            |     |                                                                      |
| Hinges                        | As specified by the KS standard (KS4619) | Per each manufacturer                                                  |                            |     |                                                                      |
| Door rollers                  | As specified by the KS standard | Per each manufacturer                                                  |                            |     |                                                                      |
| Crescents                     | As specified by the KS standard | Per each manufacturer                                                  |                            |     |                                                                      |
| Rails                         | As specified by the KS standard | Per each manufacturer                                                  |                            |     |                                                                      |
| Floor hinges &amp; door closers   | Consecutive opening/closing test, closing velocity test, stopping force test, door closing location test, operating temperature range test, durability test |                            | 1 set of testing doors     |     |                                                                      |
| Transparent glasses           | Appearance, thickness, bending | Per each manufacturer                                                  | 2                          |     |                                                                      |</p>
<table>
<thead>
<tr>
<th>Material</th>
<th>Item</th>
<th>Method</th>
<th>Frequency</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Textured glasses</td>
<td>Appearance, thickness, bending</td>
<td>BS EN</td>
<td>1. Per each tool 2. Per each quality change</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Dry cement mortar</td>
<td>Compressive strength, water-retentive air content, sand content &amp; maximum size</td>
<td>BS EN</td>
<td>Per every 1,000m³</td>
<td>1 sack</td>
<td>Classified into conventional plastering, masonry and floor</td>
</tr>
<tr>
<td>Metal laths</td>
<td>Weight, R (horizontal), S (vertical)</td>
<td>BS EN</td>
<td>1. Per each tool 2. Per each quality change</td>
<td>1 set x 3</td>
<td>Field test</td>
</tr>
<tr>
<td>Brass non slips</td>
<td>Appearance, dimension, tension test, bending test, hardness test, strain-rate</td>
<td>BS EN</td>
<td>Per every 500 materials</td>
<td>3</td>
<td>2. Field test: appearance, dimension</td>
</tr>
<tr>
<td>Floor strengthening materials</td>
<td>Compressive strength, adherence strength, abrasion test</td>
<td>BS EN</td>
<td>1. Per each tool 2. Per every 1,000 for every 1,000 materials</td>
<td>1 sack</td>
<td></td>
</tr>
<tr>
<td>Class 1, 2, 3 thermal insulating mortar</td>
<td>Thermal conductivity, flame retardancy, bond strength</td>
<td>BS EN</td>
<td>1. Per each tool 2. Per every 1,000 m²</td>
<td>1 set x 12</td>
<td>Thermal insulating mortar, 1 sack, Primer 1/</td>
</tr>
<tr>
<td>Ceramic tiles</td>
<td>Inconsistency of distortion &amp; dimension, appearance, absorption rate, crack resistance, abrasion resistance, fracture strength</td>
<td>BS EN</td>
<td>Per every 1,000 boxes</td>
<td>1 set x 10</td>
<td>Field test: appearance, dimension, absorption rate</td>
</tr>
<tr>
<td>Ceramic tile, semi-vitreous tiles</td>
<td>Inconsistency of distortion &amp; dimension (concave, convex, idle), appearance, dimension, absorption rate, fracture strength</td>
<td>BS EN</td>
<td>Per every 1,000 boxes</td>
<td>1 set x 10</td>
<td>Field test: appearance, dimension, absorption rate</td>
</tr>
<tr>
<td>Natural stone tiles</td>
<td>Appearance, dimension, absorption rate, crack resistance, abrasion resistance, fracture strength at every 1cm interval</td>
<td>BS EN</td>
<td>Per every 1,000 boxes</td>
<td>1 set x 10</td>
<td>Field test: appearance, dimension, absorption rate</td>
</tr>
<tr>
<td>Artificial marble tiles</td>
<td>Specific gravity and absorption rate</td>
<td>BS EN</td>
<td>Per each manufacturer</td>
<td>3 × 3 × 10 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bending strength</td>
<td>BS EN</td>
<td>3 × 10 × 10 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abrasion resistance</td>
<td>BS EN</td>
<td>3 × 5 × 10 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Chemical resistance</td>
<td>BS EN</td>
<td>6 × 2 × 10 cm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terrazzo tiles</td>
<td>Bending, fracture load, debonding, loosening, distortion</td>
<td>BS EN</td>
<td>Per each manufacturer</td>
<td>3</td>
<td>Add 7 if standard deviation from the manufacturer is unavailable</td>
</tr>
<tr>
<td>Terrazzo boards</td>
<td>Bending strength, aggregate rate, distortion</td>
<td>BS EN</td>
<td>Per each manufacturer</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

6-16
(2) Regulations relative to “Quality Test Standards” are as below, and it is given that they are parts of the test standards. The standards which their testing methods are specified in the “Quality Test Standards” are specified in the relative clauses.

### Appendix 3. Required Qualifications for Test/Inspection Personnel

<table>
<thead>
<tr>
<th>Class</th>
<th>Academic requirements</th>
<th>Technical requirements</th>
</tr>
</thead>
</table>
| Special Quality manager | PhD degree in Architectural Engineering with more than 3 years of experience in construction quality management  
Master's degree in Architectural Engineering with more than 9 years of experience in construction quality management  
Bachelor's degree in Architectural Engineering with more than 12 years of experience in construction quality management  
Architecture major in a junior college with more than 15 years of experience in construction quality management  
More than 10 years of experience in construction quality management at a national testing organization specified in Article 48, paragraph 1 of Enforcement Decree of the Construction Technology Management Act or at a quality testing institution specified in Article 25, paragraph 1 of Construction Technology Management Act | Construction quality test engineer  
Architect with more than 10 years of experience in construction  
Architectural engineer with more than 13 years of experience in construction  
Architectural materials test engineer with more than 8 years of experience in construction  
Architectural materials test industry engineer with more than 11 years of experience in construction quality management  
Engineer with more than 10 years of experience in construction quality management quality qualification with more than 13 years of experience in construction quality management |
| Senior Quality manager | PhD degree in Architectural Engineering with more than a year of experience in construction quality management  
Master's degree in Architectural Engineering with more than 6 years of experience in construction quality management  
Bachelor's degree in Architectural Engineering with more than 9 years of experience in construction quality management  
Architecture major in a junior college with more than 12 years of experience in construction quality management  
Graduation from a vocational high school with more than 15 years of experience in construction quality management  
More than 7 years of experience in construction quality management at a national testing organization specified in Article 48, paragraph 1 of Enforcement Decree of the Construction Technology Management Act or at a quality testing institution specified in Article 25, paragraph 1 of Construction Technology Management Act | Architect with more than 7 years of experience in construction  
Architectural engineer with more than 10 years of experience in construction  
Architectural materials test engineer with more than 5 years of experience in construction  
Architectural materials test industry engineer with more than 8 years of experience in construction  
Engineer with more than 7 years of experience in construction quality management qualification with more than 13 years of experience in construction quality management |
<table>
<thead>
<tr>
<th>Class</th>
<th>Academic requirements</th>
<th>Technical requirements</th>
</tr>
</thead>
</table>
| Junior quality manager| Master’s degree in Architectural Engineering with more than 3 years of experience in construction quality management  
 Bachelor’s degree in Architectural Engineering with more than 6 years of experience in construction quality management  
 Architecture major in a junior college with more than 9 years of experience in construction quality management  
 Graduation from a vocational high school with more than 12 years of experience in construction quality management  
 More than 5 years of experience in construction quality management at a national testing organization specified in Article 48, paragraph 1 of Enforcement Decree of the Construction Technology Management Act or at a quality testing institution specified in Article 25, paragraph 1 of Construction Technology Management Act | Architect with more than 4 years of experience in construction  
 Architectural engineer with more than 7 years of experience in construction  
 Architectural materials test engineer with more than 2 years of experience in construction  
 Architectural materials test industry engineer with more than 5 years of experience in construction  
 Architectural materials test technician with more than 7 years of experience in construction  
 Engineer with more than 4 years of experience in construction quality management qualification with more than 13 years of experience in construction quality management  
 Industry engineer with more than 7 years of experience in construction quality management |
| Intermediate quality manager | Bachelor’s degree in Architectural Engineering with more than a year of experience in construction quality management  
 Architecture major in a junior college with more than a year of experience in construction quality management  
 Graduation from a vocational high school with more than 3 years of experience in construction quality management  
 More than 2 years of experience in construction quality management at a national testing organization specified in Article 48, paragraph 1 of Enforcement Decree of the Construction Technology Management Act or at a quality testing institution specified in Article 25, paragraph 1 of Construction Technology Management Act | Architect with more than a year of experience in construction  
 Architectural industry engineer with more than a year of experience in construction  
 Architectural materials test engineer/architectural materials test industry engineer/architectural materials test technician  
 Engineer with more than a year of experience in construction quality management qualification with more than 13 years of experience in construction quality management  
 Industrial engineer with more than a year of experience in construction quality management qualification with more than 13 years of experience in construction quality management |
### Appendix 4. Provision of Testing Equipment for Field & Lab Tests

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Dimension</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Compressive strength tester (incl. pressure pipe)</td>
<td>Larger than 100t (minimum gauge scale of 200kg)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2. Specimen mold (incl. vibrator poker)</td>
<td>Ø15×30cm/Ø10×20cm</td>
<td>8 sets x 24/8 sets x 24</td>
<td>For aggregates thinner than 25mm</td>
</tr>
<tr>
<td>3. Slump con (incl. compaction frame, support plate)</td>
<td>Ø10×20×30cm</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>4. Net</td>
<td>#4/~#200</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>5. Filed net</td>
<td>ØEA</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>6. Scale</td>
<td>Volume Sensitivity</td>
<td>1</td>
<td>Digital type capable of underwater weight measuring</td>
</tr>
<tr>
<td></td>
<td>2kg Less than 0.1g</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25kg Less than 0.5g</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50Kg Less than 1g</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7. Specimen separator</td>
<td>Quentain Campus</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>8. Specific-gravity test flask</td>
<td>500cc</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>9. Dryer</td>
<td>150°C</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>10. Mass cylinder</td>
<td>500cc</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11. Mixing fan</td>
<td>100×100×7cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>12. Curing water tank (incl. constant temp water tank)</td>
<td>Larger than 1.0×1.0×0.8m</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>13. Other net, brush, thermometer</td>
<td></td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>14. Bending strength tester</td>
<td></td>
<td>1</td>
<td>If necessary</td>
</tr>
<tr>
<td>15. Moisture content measurer</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>16. Vernier calipers</td>
<td>Longer than 30cm</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>17. Micrometer</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>18. Air-content measurer</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>19. Container</td>
<td>Larger than 5ℓ with a circular base</td>
<td>1</td>
<td>For washing analysis (concrete)</td>
</tr>
<tr>
<td>20. Concrete test hammer (Schmidt hammer)</td>
<td></td>
<td>1</td>
<td>Incl, test anvil</td>
</tr>
<tr>
<td>21. Salinity meter</td>
<td></td>
<td>1</td>
<td>With printing function</td>
</tr>
<tr>
<td>22. Thermal insulator cutter (incl. hot wires)</td>
<td>0~100V</td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>23. Cone-type mold (incl. vibrator poker)</td>
<td></td>
<td>1 set</td>
<td></td>
</tr>
<tr>
<td>24. Desicato</td>
<td>Small, large</td>
<td>1EA</td>
<td></td>
</tr>
<tr>
<td>25. Straight steel ruler &amp; tapeline)</td>
<td>Longer than 2m, 3m</td>
<td>1EA</td>
<td></td>
</tr>
<tr>
<td>26. Mount board</td>
<td>Bigger than 1.0×2.0m</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

* Required specifications of salinity meter
1. Measuring method: Chloride ion electrode
2. Measuring range: 0.001-1.5% chloride ion concentration (cl/water)
3. Measurement error range: Within 0.1-0.5±10% (cl/water) chloride ion concentration
4. The salinity meter should be easy to handle, sufficient durable, and be able to produce results in 10 minutes.
Appendix 5. Quality Manager’s Construction Confirmation

A. Times & scopes of construction confirmation works

<table>
<thead>
<tr>
<th>Work</th>
<th>Time of Confirmation (Inspection)</th>
<th>Scope of Confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per unit</td>
</tr>
<tr>
<td>1. Temp construction</td>
<td>. After installation of temp buildings</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td>. After installation of buildings</td>
<td></td>
</tr>
<tr>
<td>2. Civil works</td>
<td>. After foundation excavation</td>
<td>100%</td>
</tr>
<tr>
<td>3. Reinforced concrete</td>
<td>. After foundation lean concrete placement and irk lining</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. After preparation of foundation concrete placement</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. During placement of foundation concrete</td>
<td>x2/day</td>
</tr>
<tr>
<td></td>
<td>. After removal of foundation form</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. After wall rebar installation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After preparation of concrete placement</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. During concrete placement</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. After form removal</td>
<td>x2/day</td>
</tr>
<tr>
<td>4. Masonry works</td>
<td>. After preparation</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>. After masonry</td>
<td>30%</td>
</tr>
<tr>
<td>5. Metal railing installation</td>
<td>. After railing installation</td>
<td>50%</td>
</tr>
<tr>
<td></td>
<td>. After stairway railing installation</td>
<td>50%</td>
</tr>
<tr>
<td>6. Asphalt (Sheet</td>
<td>. After preparation of asphalt (sheet) waterproofing</td>
<td>100%</td>
</tr>
<tr>
<td>waterproofing)</td>
<td>. During asphalt (sheet) waterproofing</td>
<td>x2/day</td>
</tr>
<tr>
<td></td>
<td>. After asphalt (sheet) waterproofing</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. After preparation of press concrete placement</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. After press concrete placement</td>
<td>100%</td>
</tr>
<tr>
<td>7. Cement liquid</td>
<td>. After preparation of cement liquid waterproofing</td>
<td>30%</td>
</tr>
<tr>
<td>waterproofing</td>
<td>. After cement liquid waterproofing</td>
<td>30%</td>
</tr>
<tr>
<td>8. Mortar waterproofing</td>
<td>. After preparation of mortar waterproofing</td>
<td>30%</td>
</tr>
<tr>
<td>9. Carpentry &amp; thermal</td>
<td>. After installation of wall frame &amp; thermal insulation</td>
<td>30%</td>
</tr>
<tr>
<td>insulation</td>
<td>. After installation of ceiling frame</td>
<td>30%</td>
</tr>
<tr>
<td>10. Roof tiling</td>
<td>. After treatment of base surface</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>. After roof tiling</td>
<td>100%</td>
</tr>
<tr>
<td>11. Asphalt shingle</td>
<td>. After preparing base surface of asphalt bolts</td>
<td>100%</td>
</tr>
<tr>
<td>installation</td>
<td>. After installation of asphalt shingles</td>
<td>100%</td>
</tr>
</tbody>
</table>
### 6. Architectural Specification

<table>
<thead>
<tr>
<th>Work</th>
<th>Time of Confirmation (Inspection)</th>
<th>Scope of Confirmation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Per unit</td>
</tr>
<tr>
<td>12.</td>
<td>Gutter &amp; storm sewer</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After installation of gutter for balcony, hallway</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>. After installation of storm sewer &amp; manhole</td>
<td>100%</td>
</tr>
<tr>
<td>13.</td>
<td>Windows work (Wooden windows, synthetic resin windows, metallic windows, aluminium windows, extruded windows, frames, finish hardwares)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After installation of door/window frame</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After installation of door, window, finish hardware</td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Glass works</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After glass installation</td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Cement mortar plastering</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After initial plastering on interior/exterior walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After main plastering on interior/exterior walls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After plastering on balcony/hallway surbase and vicinity of railing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>. After plastering on underground wall/floor</td>
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<td>16.</td>
<td>Terrazzo &amp; artificial stone installation</td>
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<td></td>
<td>. After preparation of terrazzo/artificial stone installation</td>
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<td>. After terrazzo/artificial stone installation</td>
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<td>17.</td>
<td>Floor surface finishing</td>
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<td></td>
<td>. After installation of floor thermal insulation and filling with gravels</td>
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<td>. After floor plastering</td>
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<td>18.</td>
<td>Tiling works</td>
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<td>. After wall tiling of restroom</td>
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<td>. After wall tiling of kitchen</td>
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<td>. After floor tiling of restroom</td>
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<td>. After floor tiling of balcony/entrance</td>
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<td>19.</td>
<td>Plaster/cement boards</td>
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<td></td>
<td>. After installation of plaster board on wall/ceiling</td>
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<td>20.</td>
<td>Coating works</td>
<td></td>
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<td></td>
<td>. After initial coating of indoor</td>
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<td>. After main coating of indoor</td>
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<td>. After main coating of outdoor</td>
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<td>. After initial coating on wooden part</td>
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<td>. After main coating on wooden part</td>
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<td>. After initial coating on metallic part</td>
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<td>. After main coating on metallic part</td>
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<td>21.</td>
<td>Elastic floor materials</td>
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<td></td>
<td>. After laying floor material</td>
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<td>22.</td>
<td>Papering works</td>
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<td>. After initial papering</td>
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<td></td>
<td>. After main papering</td>
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<tr>
<td>23.</td>
<td>Other</td>
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<td>. After completion cleaning</td>
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</table>
**B. Major confirmation items by time periods**

<table>
<thead>
<tr>
<th>Work</th>
<th>Time of Confirmation</th>
<th>Major Items</th>
</tr>
</thead>
</table>
| 1. Temp construction | During temp buildings arrangement | 1. Main building  
(sufficient distance from road/land/auxiliary facilities boundaries)  
2. Appropriateness of temp building locations  
(temp offices, test lab, storeroom, cafeteria, accommodations, temp restroom)  
3. Pollution prevention installations  
(Wheel washer, dustproof mesh, incinerator)  
4. Appropriateness of workshop & storage yard  
5. Interference with related construction (water supply lines, gas/telecommunication lines)  
6. Time of demolition to commence succeeding works  
(paving, draining, landscaping & exterior works) |
| 2. Civil works | After foundation excavation | Land boundary  
BM location, ground level  
Main & sub BM installation  
Boundary point (w/ boundary indication survey)  
Installation of artificial and ancillary points  
2. Design ground level  
Ground level survey prior to foundation excavation  
Foundation drawing, land plan, design level on the building layout)  
3. Building arrangement  
Conformance of building arrangement with the layout  
Distances between the buildings, distances from the land/road boundaries  
Longitudinal/transverse dimension of the whole complex |
2. Thickness & smoothness of the lean concrete  
3. Finishing of the posts & installation of blocking hollow  
4. Necessity of a reinforcement if different from design locations of posts |
| | After preparation of foundation lean concrete placement | 1. Site coefficients (based on the foundation work data)  
2. Placement of foundation rebar & installation of rebar binder  
3. Rebar placement at the joint with the utility tunnel  
4. Fixation of rebar for maintaining the coating thickness of vertical rebar for retaining wall & displacement  
5. Installation of horizontal brace & struts at the upper part of the foundation form  
6. Sealing of gap between the floor and the form |
| | During placement of foundation concrete | 1. Remicon mix report and invoice  
2. Remicon additivity water  
3. Conformance with the requirements  
4. Field quality test (slump, salinity measurement, air content, specimen production)  
5. Preparedness of protection materials & water spraying facilities |
### 6. Architectural Specification

<table>
<thead>
<tr>
<th>Work</th>
<th>Time of Confirmation</th>
<th>Major Items</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5. Metal railing installation</strong></td>
<td>. After railing installation</td>
<td>1. Welding status between anchor plate and railing steel</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Finishing height and vertical/horizontal status of railing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Distance from the structure (sides and bottom sill)</td>
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<tr>
<td></td>
<td></td>
<td>4. Protection of upper section after installation</td>
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<tr>
<td></td>
<td>. After stairway railing installation</td>
<td>1. Welding/fixed status of railing steel</td>
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<tr>
<td></td>
<td></td>
<td>2. Finishing height and vertical/horizontal status of railing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Distance from the floor</td>
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<tr>
<td></td>
<td></td>
<td>2. Direction &amp; bending of base surface drains</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Dryness of base surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Fixation of circular surface at the corners</td>
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<tr>
<td></td>
<td></td>
<td>5. Installation of waterproofing grooves at the bottoms of various protuberances</td>
</tr>
<tr>
<td></td>
<td>. During asphalt (sheet) waterproofing</td>
<td>1. Sequence of waterproofing works</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Status of primer coating &amp; asphalt pavement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Heating temperature of asphalt</td>
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<tr>
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<td></td>
<td>4. Existence of overlying &amp; offset of waterproofing</td>
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<td></td>
<td>5. Finishing status of winded-up section at the bottoms of protuberances</td>
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<td></td>
<td>6. Existence of swelling/detachment</td>
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<tr>
<td></td>
<td>. After (sheet) waterproofing</td>
<td>1. Water-filling test on the rooftop</td>
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<tr>
<td></td>
<td></td>
<td>- Remicon supplier</td>
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<td></td>
<td></td>
<td>- Type, performance &amp; piping of concrete pump</td>
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<tr>
<td></td>
<td></td>
<td>2. Height &amp; bending of press concrete</td>
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<td></td>
<td></td>
<td>3. Spacing &amp; fixing of contraction joints</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1. Smoothness &amp; cracks on the base surface</td>
</tr>
<tr>
<td></td>
<td>. After press concrete placement</td>
<td>2. Bending in the vicinity of the base surface &amp; drains</td>
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<td></td>
<td>3. Spacing &amp; standard of contraction joints</td>
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<td></td>
<td>4. Finishing of contraction joints corks</td>
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<tr>
<td></td>
<td>. After cement liquid waterproofing</td>
<td>1. Existence of cracks on concrete, etc.</td>
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<tr>
<td></td>
<td></td>
<td>2. Bending in the vicinity of floor drains</td>
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<td></td>
<td>3. Cleanliness &amp; smoothness of base surface</td>
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<tr>
<td></td>
<td></td>
<td>2. Water-filling test of laundry room</td>
</tr>
<tr>
<td><strong>8. Mortar waterproofing</strong></td>
<td>. After preparation of mortar waterproofing</td>
<td>1. Existence of cracks on concrete, etc.</td>
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<td></td>
<td>2. Bending in the vicinity of floor drains</td>
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<td></td>
<td>3. Cleanliness &amp; smoothness of base surface</td>
</tr>
<tr>
<td><strong>9. Carpentry &amp; thermal insulation</strong></td>
<td>. After installation of wall frame &amp; thermal insulator</td>
<td>1. Spacing &amp; fixing</td>
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<tr>
<td></td>
<td></td>
<td>2. Status of jointing &amp; filling of thermal insulator</td>
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<td>3. Reinforcement in the vicinity of electrical box</td>
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<tr>
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<td>. After installation of ceiling frame</td>
<td>1. Spacing &amp; fixing</td>
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<tr>
<td></td>
<td></td>
<td>2. Status of hanging member and carrying rod of ceiling</td>
</tr>
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<td></td>
<td></td>
<td>3. Horizontalness of ceiling frame</td>
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<tr>
<td>Work</td>
<td>Time of Confirmation</td>
<td>Major Items</td>
</tr>
<tr>
<td>-----------------------</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 10. Asphalt shingle installation | . After preparation of asphalt shingle base | 1. Smoothness & bending of base surface  
2. Dryness of base surface  
3. Guide ink line of base surface (width×length) |
| 10. Asphalt shingle installation | . After asphalt shingle installation | 1. Existence of overlaying at all sides  
2. Fixing & attaching status of shingles  
3. Cleanliness & finishing of shingles |
2. Fixing status of linear gutter  
3. Length of linear gutter |
| 12. Window works      | . After wooden window doorframe/window frame installation | 1. Verticality/horizontality/bending of members  
2. Coating of preservative at the wall joints  
3. Status of fixation steel of doorframe  
4. Verticality/horizontality/frontal & rear angle of doorframe  
3. Swelling prevention for doorframe injection  
4. Status of doorframe protection |
| 12. Window works      | . After installation of door/window steels for wooden windows | 1. Existence of twisting/bending of door  
2. Fitting of door at all sides  
3. Tightness of door  
4. Status of coated surface  
5. Status of various window steels |
| 12. Window works      | . After aluminium window doorframe/window frame installation | 1. Verticality/horizontality/bending of members  
2. Status of fixation steel of doorframe  
3. Swelling prevention for doorframe injection  
4. Status of doorframe protection |
| 12. Window works      | . After installation of door/window steels for aluminium windows | 1. Status of door (damage/fixation)  
2. Tightness of door  
3. Status of various window steels |
| 12. Window works      | . After synthetic resin window doorframe/window frame installation | 1. Fixation of slab concrete retaining wall  
2. Use of fixation steel in presence of brick surface contact  
3. Verticality/horizontality/bending of members |
2. Tightness of door  
3. Status of various window steels |
<table>
<thead>
<tr>
<th>Work</th>
<th>Time of Confirmation</th>
<th>Major Items</th>
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</thead>
<tbody>
<tr>
<td><strong>12. Window works</strong></td>
<td></td>
<td>1. Verticalness/horizontalness/bending of members</td>
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<tr>
<td></td>
<td></td>
<td>2. Frontal/rear angle of doorframe</td>
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<td>3. Height of the doorframe considering finishing floor surface</td>
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<td>4. Welding status of fixation steel</td>
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<td></td>
<td>. After installation of steel window frame/doorframe</td>
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<td></td>
<td>1. Bending of the door</td>
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<td>2. Status of rubber packing around the doorframe</td>
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<td>3. Tightness &amp; opening/closing of the door</td>
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<td>4. Status of various window hardwares</td>
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<td>5. Protection of the door</td>
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<td>. After installation of door/window hardware</td>
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<td>1. Installation height considering the frame &amp; finishing</td>
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<td>2. Verticalness/horizontalness/bending of window frame</td>
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<td></td>
<td></td>
<td>3. Status of fixation steel</td>
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<td></td>
<td>4. Filling of binding admixture at member joints</td>
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<td>5. Tightness of the exterior widow frame</td>
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<td>6. Protection of the doorframe</td>
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<td>. Extruded window</td>
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<td></td>
<td>1. Standard of the glass at each part</td>
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<td>2. Cutting/vibrating of the glass</td>
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<td>3. Tightness of the glass putty (gasket)</td>
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<td><strong>13. Glass works</strong></td>
<td>. After glass installation</td>
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<td></td>
<td></td>
<td>1. Mix &amp; thickness of cement per each base</td>
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<td>2. Location of contraction joints</td>
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<td>3. Removal of supports around the window frame</td>
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<td>4. Status of metal latch around the window openings &amp; box pipes</td>
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<td>5. Smoothness of vertical/horizontal surface</td>
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<td><strong>14. Cement mortar works</strong></td>
<td>. After initial plastering of interior/exterior walls</td>
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<td></td>
<td>1. Smoothness of the finishing surfaces</td>
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<td>2. Debonding/cracking/swelling/loosening of the plastered surface</td>
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<td>3. Corking groove cut &amp; status around the window frame</td>
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<td>4. Status of joints</td>
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<td></td>
<td>. After main plastering of interior/exterior walls</td>
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<td></td>
<td></td>
<td>1. Finishing height/verticalness/horizontalinales</td>
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<td>2. Distance between the railing &amp; structure</td>
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<td>3. Flatness of the surbase surface</td>
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<td>4. Debonding/cracking/smoothness around the railing fixation steels</td>
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<td>. After plastering of hallway surbase &amp; vicinity of railing</td>
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<td></td>
<td></td>
<td>1. Smoothness of base surface</td>
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<td></td>
<td>2. Cracking/debonding of the base surface</td>
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<td>3. Thickness of the cement on the base surface</td>
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<td>4. Installation of trench collecting well &amp; bending of drains</td>
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<tr>
<td>Work</td>
<td>Time of Confirmation</td>
<td>Major Items</td>
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<td>-----------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 15. Floor finishing works           | After floor insulator works & gravel filling | 1. Ink lining of the baseline for wall surface  
2. Location & finishing of the header box  
3. Status of the thermal insulator  
4. Verticalness/horizontalness of the entrance log frame  
5. Status of gravel filling  
6. Cracking & protection status at the bottoms of various doorframes |
|                                    | After floor plastering | 1. Smoothness of the base surface  
2. Cracking & debonding of the base surface  
3. Removal of contaminants from the doorframe & wall |
| 16. Tiling works                    | After wall tiling of kitchens & restrooms | 1. Smoothness of the tiled surface  
2. Bonding of the tiles & finishing of joints  
3. Status of mortar  
4. Debonding & cracking of the tiles  
5. Conformance with the procedure & drawing |
|                                    | After floor tiling of restrooms/balcony/entrance | 1. Smoothness of base surface & maintenance  
2. Bonding of the tiles & finishing of joints  
3. Debonding & cracking of the tiles  
4. Conformance with the procedure & drawing |
| 17. Plaster board & cement plate    | After installation of wall/ceiling plaster board | 1. Horizontal/vertical fixation of the finishing materials  
2. Status of precise construction of the finishing materials |
| 18. Coating works                   | After initial coating of interior/exterior/roof tiles | 1. Overlap construction of paints  
2. Sequence & number of the coatings  
3. Status of polishing & filler  
4. Color-finishing plan for each section |
|                                    | After main coating of interior/exterior/roof tiles | 1. Drying time after the initial coating  
2. Number of the coatings  
3. Thickness & finishes of the coating  
4. Overlap construction of paints |
|                                    | After initial wood coating | 1. Number of the coatings  
2. Status of the wood primer coating after sanding  
3. Polished status of the base surface filler  
4. Material for each coating type |
|                                    | After main wood coating | 1. Drying time after the initial coating  
2. Thickness of the coating  
3. Number of the coatings  
4. Finishing status |
### 6. Architectural Specification

<table>
<thead>
<tr>
<th>Work</th>
<th>Time of Confirmation</th>
<th>Major Items</th>
</tr>
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<tbody>
<tr>
<td>Coating works</td>
<td>After initial steel coating</td>
<td>1. Status of the rustproof coating on the base surface (debonding)</td>
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<tr>
<td></td>
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<td>2. Slag removal &amp; polished status of the welded joints</td>
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<td></td>
<td>3. Removal of contaminants from the base surface</td>
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<tr>
<td></td>
<td>After main steel coating</td>
<td>1. Thickness of the coating</td>
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<tr>
<td></td>
<td></td>
<td>2. Number of the coatings</td>
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<tr>
<td></td>
<td></td>
<td>3. Finished status</td>
</tr>
<tr>
<td>Elastic floor materials</td>
<td>After laying floor materials</td>
<td>1. Butt joint of connecting piece</td>
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<tr>
<td></td>
<td></td>
<td>2. Decoloration &amp; alteration</td>
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<tr>
<td></td>
<td></td>
<td>3. Boding status of the base surface</td>
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<td></td>
<td>4. Conformance with the drawing</td>
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<td>5. Status of the lower part of the wall (levelling: 5cm)</td>
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<td>6. Thorough adhesive coating around the entrance</td>
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<td>(slipping prevention)</td>
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<tr>
<td>Papering works</td>
<td>Initial papering</td>
<td>1. Smoothness of base surface</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Status of the initial papering at the joints of the plaster boards</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Polished status of the base surface after the initial papering</td>
</tr>
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<td></td>
<td>4. Omission &amp; dryness of the initial papering</td>
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<tr>
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<td>5. Fixing nails (rustproof) &amp; their spacing (within 15cm) on the plaster</td>
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<tr>
<td></td>
<td></td>
<td>boards</td>
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<tr>
<td></td>
<td>Main papering</td>
<td>1. Matching of the colors &amp; overlaying</td>
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<tr>
<td></td>
<td></td>
<td>2. Debonding at the edges</td>
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<tr>
<td></td>
<td></td>
<td>3. Decoloration of the wallpapers</td>
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<tr>
<td></td>
<td></td>
<td>4. Verticality/horizontality of the finishing lines</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ceiling in the vicinity of doorframes, wall edges)</td>
</tr>
<tr>
<td>Other</td>
<td>After completion cleaning</td>
<td>1. Cleanness of glasses &amp; doorframes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Water cleaning of the restrooms &amp; balconies</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Finishes of the waxing on the stairwells &amp; hallways</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4. Statuses of the protections after cleaning</td>
</tr>
</tbody>
</table>
Chapter 2. Temporary Facilities

Temporary Construction

1. General

1.1 Scope

This specification is applied to all the works related to construction of temporary facilities.

1.2 Applied Standards

It is given that the following standards are applied in this specification within the indicated scope.

1.3 Submissions

The followings shall be submitted in accordance with the "Submissions & Project Administration Documents"

1.3.1 Construction Plan

(1) Construction plan with regards to installation, material transportation, removal works that are related to the temporary constructions
(2) The type, magnitude, location, and removal schedule of each temporary facility shall be included.

1.3.2 Detailed Construction Documents

(1) Layouts of the temporary offices
(2) Design drawings of the owner’s office (floor plan, front elevation)
(3) Installation drawings of temporary materials (steel pipe scaffolds, etc.)
1.3.3 Samples
The following product samples provided by the manufacturers:
(1) Finishing materials of the temporary facilities
(2) Examples of the temporary facilities

2. Materials
New products should be used as materials in principle. The 19 material types that are subject to performance tests shall be certified and indicated clearly of the test agency.

3. Construction

3.1 Geodetic Surveys & Building Layouts
Geodetic surveys and building layouts shall be approved immediately before commencing the works.

3.2 Batter Boards
3.2.1 Horizontal Batter Boards
(1) Horizontal batter boards shall be installed along the exterior columns in case reinforced concrete buildings, and at corners and major parts in case of masonry buildings.
(2) Horizontal batter boards shall be clearly indicated of their horizontal baselines and building locations with ink linings in order to be approved and to subsequently mark on the buildings themselves as the construction progresses.

3.2.2 Vertical Batter Boards
(1) Vertical batter boards shall be installed perpendicularly to the joints between retaining walls with the quantity of the blocks or bricks clearly indicated.
(2) Vertical batter boards shall be made of dry wooden materials free of twisting bending. Two 90mm surfaces shall be planed perpendicularly to each other and fixed with braces of struts. If installed on a concrete deck, they shall be accurately installed by burying steel wires, etc.
3.3 Ink Linings

Building locations, horizontal baselines, placement of masonry materials shall be indicated with ink linings and approved.

3.4 Control points

(1) Civil control points shall be used.

(2) Sub-control points shall be approved by the project manager with submission of the survey results. Sub-control points shall also be installed at locations without probable relocation or modification, and protected with fences, etc.

3.5 Temporary Buildings (Temporary Facilities)

Standards by the ministry of construction & transportation shall be applied to determine the magnitudes of the temporary buildings (temporary building can also be used for civil works under approval of the project manager).

3.6 Scaffolds

3.6.1 Steel Pipe Scaffolds

(1) Materials

Only certified products shall be used as members or accessories, with exceptions to those are approved by the project manager.

(2) Composition of Steel Pipe Scaffolds

① Columns

Columns shall be spaced 1.5-1.8m longitudinally and 0.9-1.5m in beam direction with their bases below 31m measured from the top tied with two steel pipes.

② Wales

Wales shall be spaced within 1.5m with the first wale installed on the ground being lower than 2m.

③ Joists

Joists shall be spaced within 1.5m, and connected to the column where a column and wale cross with connection to the wale in the middle.
4. Braces

Braces shall be spaced within 15m horizontally while angled at 45˚ and connected to the column and wale. They shall be installed as required.

5. Pilaster Masses & Connections with Structures

Connections to the structures shall be securely made with a horizontal and vertical spacing within 5.0m, or by installing durable pilaster masses.

6. Bases

Bases of the columns shall be equipped with metal fittings and then connected to the adjacent column with base fixation. More than three connected supporting boards with required widths shall be laid in case of soft ground. However, base fixation can be omitted if the supporting boards are fixed with metal fittings.

7. Accessories

When using a particular accessory, it shall be sufficiently durable against the stress occurred at the location.

(3) Limit Loads

The load applied to between the columns shall be limited to 400kg for columns with a spacing of 1.8m, and can be increased in a reversed ratio if the spacing between the columns is less than 1.8m. The limit load of a single column shall be 700kg if more than three floors.

(4) Exceptions

In cases of entrances or openings, or special circumstances such as loads applied to scaffold boards, safety shall be secured by calculating the strength to suit the purpose.

3.6.2 Steel Pipe Scaffolds

(1) Members & Auxiliary Steels

Only certified products shall be used as members or accessories, with exceptions to those are approved by the project manager.

(2) Composition of Steel Pipe Scaffolds

1. Foundation

Metal fittings shall be applied to the bases of columns. In case of a different elevation between the bases, adjustable metal fittings shall be used to maintain horizontalness and verticalness of each scaffold. For soft grounds, supporting boards shall be provided at the
base of the metal fittings in order to secure an adequate grounding area.

2. **Braces, Wales & Horizontal Members**

Braces or equivalent materials shall be installed between the vertical frames while horizontal members such as linear wale shall be installed at the top floor or every 5 floors. Braces shall be assembled tightly against vibrations by using pins or screws. If a brace needs to be partially removed due to circumstances, horizontal members or linear wales shall be installed above and below the location.

3. **Connections with Structures**

Horizontal frames shall be securely connected to structures with a vertical spacing within 6m and horizontal spacing within 8m.

4. **Support Frames**

If the length is less than 4m and the height exceeds 10m longitudinally, support frames that are longitudinally effective shall be installed for the heights within 10m.

5. **Height**

In principle, the height shall not exceed 45m. For heights exceeding 20m and heavy-duty works, strength-wisely important frames shall be lower than 1.8m with a installation spacing within 1.8m. However, the height and spacing may be increased if a sufficiently safe frame is used at a scaffold leg or opening, etc.

6. **Beam Frames & Cantilever Frames**

Lateral vibration should be prevented by using horizontal braces, etc.

(3) **Limit Loads**

The load applied to between the frames shall be limited to 400kg for frames with a spacing of 1.8m, and can be increased in a reversed ratio if the spacing between the frames is less than 1.8m. The limit vertical load per each scaffold column shall be 2,500kg in case of a storing foundation, but should be lowered in case of a buckled supporting board, possible settlement, or special composition.

3.6.3 **Scaffold Legs**

At least one scaffold leg shall be installed per each building based on the following criteria:

1. Shall be wider than 90cm with a slope of 4/10. A scaffold legs shall be installed at each floor (or at every 7m height in case of no distinction of floors) to provide access.
6. Architectural Specification

(2) For locations where falling may occur, a handrail with an approximate height of 90cm shall be securely installed at the scaffold column or wale.

(3) 1.5cm×3.0cm large non-slips shall be installed at every 30cm of footholds.

### 3.6.4 Footholds

(1) 2.5-3.5m long knots or boards with a minimum width of 25cm and a minimum thickness of 4cm, or a certified foothold shall be used.

(2) Footholds shall not exceed more than 20cm from the wale when spreaded, with their connections securely fixed without debonding or moving on the joists, etc.

### 3.6.5 Handrails

(1) Handrails shall be higher than 90cm and tightly installed to prevent deformation and disconnection.

(2) A mid-rail should be installed at 45cm if the handrail is deemed too high.

### 3.7 Various Construction Facilities

Lighting, power and other various construction facilities should be installed accordingly to the circumstances. River water or well water should be used as construction water in principle.

### 3.8 Safety Facilities

#### 3.8.1 Safety Handrails

Safety handrails made of steel pipes (Φ48.6, t:2.4mm), etc. shall be installed at fall risk sections with a horizontal spacing of 45cm and 90cm and a vertical spacing within 180cm.

#### 3.8.2 Horizontal Opening Protection Covers

Protection covers made of 12mm plywoods and 45×45cm rectangular bar or equivalent shall be installed at horizontal openings.

#### 3.8.3 Fall Prevention Nets

A fall prevention net with a higher tensile strength than 180km shall be installed at every two floors of fall risk areas such as opening areas of pump stations.
3.8.4 Dropping Prevention Nets

(1) A dropping prevention net shall be installed at every 10m in height or every three floors.

(2) A dropping prevention net shall have an extension distance more than 2m from the outside of the scaffold, and an overlaying distance of 15cm. The angle between a horizontal surface and a dropping prevention net shall be 20°-30°.

(3) Struts made of steel pipes, etc. (Φ48.6, t:2.4mm) shall be installed with a horizontal spacing within 1m and a vertical spacing within 1.8m.

(4) There should be no gap between an exterior scaffold and a wall when installing a dropping prevention nets.

3.8.5 Safety Signs

(1) Access restriction signs: At entrances of areas such as hazardous material storage, material storage, boiler room, etc.

(2) Enlightenment signs: One set (4 types) each installed at main entrances and main access ways.

(3) Safety signs: One each a front, rear, left, right sides of buildings and at material processing area.

(4) Banners: One banner each for every two buildings

(5) Non-disaster record board & safety instructions: In front of a construction office or on the corresponding equipment.

3.9 Clearances

Infusible wastes produced from the works shall be immediately carried outside in order to prevent impacts on plants. Inevitably produced wastes shall be treated in accordance with the regulations, and the areas shall be thoroughly cleaned prior to the completion test.
6. Architectural Specification

3.10 Special Notes

3.10.1 Control Points

<table>
<thead>
<tr>
<th>Installation location</th>
<th>No. of locations</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>As instructed by the project manager</td>
<td>4</td>
<td>As per civil works standards</td>
</tr>
</tbody>
</table>

3.10.2 Scaffolds & Footholds

<table>
<thead>
<tr>
<th>Type</th>
<th>Main material</th>
<th>Foothold</th>
<th>Joint</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exterior scaffold</td>
<td>Steel pipe</td>
<td>Safety foothold</td>
<td>Clamps</td>
<td></td>
</tr>
<tr>
<td>Interior horizontal scaffold</td>
<td>Fabricated frame</td>
<td>Safety foothold</td>
<td>Pins or iron wire</td>
<td></td>
</tr>
<tr>
<td>Scaffold leg</td>
<td>Steel pipe</td>
<td>Safety foothold</td>
<td>Clamps or iron wire</td>
<td></td>
</tr>
</tbody>
</table>

3.10.3 Temporary Supports at Openings of Structures

Since the subsequent work can be continued only after completion of sub structures at openings of structures (e.g. filter of a stilling basin), if temporary supports for the super structure are conventionally installed (after installation of B/T scaffolds), it would cause enormous impacts on the subsequent works. Therefore, temporary supports shall be installed as below and may be adjusted as approved by the project manager:

(1) Preparations

Temporary supports shall be installed in accordance with the followings after their approval by the project manager:

A. Installation plan

B. Shop drawings

C. Structural review of the temporary facilities (by architect)

(2) Installation Method (Reference Only)

Once the structure works have been completed, install H-beams (H-300x300x10x15 or larger) within every 900m/m, and then lay conventional rectangular bars (84x84 or larger) at every 225m/m perpendicularly to the H-beams, followed by securely laying form plywood (thickness=12m/m) on top as safety footholds fixed with nails.

As from (super structure) work progresses, lay rectangular bars (84x84 or larger) accordingly to the location of each support (spaced within 900m/m) in sequence during work.
Septic Tank Installation

Chapter 1 : Scope
A FRP filament winding type septic tank authorized by the Minister of Environment and installed in compliance with Sewage Act.

Chapter 2 : Contractor’s Responsibilities
The contractor shall comply to relevant regulations during execution of the installation works, and also shall follow Waste Control Act.

Chapter 3 : Safety
A safety manager who can oversee the whole safety issues regarding foundation excavation shall remain on site.

1) Scope
This specification describes NUV for sterilization (deodorization) and vermin extermination of wall-mounted type septic tank.

2) General
The septic tank shall be installed in accordance with this specification unless specified otherwise by design document, relevant law or regulation.

All mechanical and electrical works shall be referred to the their specifications.
If there is a substantial difference between the specification and the drawing, it shall be interpreted by the project manager.
If any of the methods, materials, or products designated by this specification, drawings or manuals is realistically impossible to adopt, it should be reported to the project manager on paper and approved before proceeded.

3) Guidelines
All works should be executed in compliance of relevant laws (including regulations).
All works should be thoroughly executed to fully enable utilities of the facilities. Matters that are not specified but deemed necessary should also be addressed.
All works shall be executed only after submitted drawings have been approved by the project manager.

4) Materials & Equipment
All materials and equipment should be KS certified or equivalent and should be used only after approved by the project manager. Energy-saving materials and equipment should be procured from registered manufacturers of Rational Energy Utilization Act.

5) Performance Requirement
The performance should be fully maintained while operated 24 hours, 365 days.

6) Basic Specification
Size: 300mm(L) x 100mm(D) x 520mm(H)
Casing material: STS 304
Voltage & power : 220V, 110W
Input: 0.5A, 60HZ

7) Detailed Specification
(1) The following NUV and ozone lamps shall be used:
① UV wavelength: 184.9nm
② UV emission : 30,000㎼/sec
③ Effective lifespan : More than 10,000
④ Capacity & quantity: 39W x 2
⑤ Power socket shall be 1-pin type made of teflon.
⑥ Shall be certified of international standard
(2) Stabilizers should be waterproofed by coal tar, embedded with a fuse, and exclusively made for NUV and ozone lamps.
(3) Exposed wires should be made of teflon.
(4) Fans should be made of metallic and PP materials, and maintain an air volume $6 \pm 0.5 \text{ m}^3$/per minute. Also, the fans should have their input terminals and bearing parts waterproofed,
and include a built-in thermal control device to automatically lower the heat during extensive operation.

(5) Fuses shall be installed on the cases and the wires should be made of teflon

(6) Numerous perforated plates should be used for air-vents for stability.

(7) A timer should be provided in order to adjust operation time as necessary.

(8) Cases should be made of stainless steel.

8) Installation

(1) The following NUV and ozone lamps shall be used. They shall be wall-mounted by matching the holes on the upper rear of the sterilizer casing.

(2) Specification

<table>
<thead>
<tr>
<th>Name</th>
<th>Specification</th>
<th>Power</th>
<th>Qty</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>NUV sterilizer</td>
<td>7.4G/HR</td>
<td>0.1KW</td>
<td>1 set</td>
<td>STS</td>
</tr>
</tbody>
</table>
Chapter 3. Supplement

Residing Engineer’s Office

1. Residing Engineer’s Office

- The contractor should provide an office and a temporary lab.
- The office should be located at the center and as agreed by the engineer.
- The office should be protected from weather and insects, sufficiently air-circulated, heat insulated, well-lighted, equipped with safety locks, and painted. The followings are sizes and numbers of the rooms defined by the engineer. A paved parking space large enough for at least six vehicles with four of them being roofed.

<table>
<thead>
<tr>
<th>#</th>
<th>Classification</th>
<th>Size</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Residing engineer</td>
<td>4 m × 4 m</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Residing engineer’s assistant</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Meeting room</td>
<td>5 m × 4 m</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Surveyor</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>Typist/filing</td>
<td>4 m × 4 m</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>Restroom</td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>9.</td>
<td>Storeroom</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>Kitchen</td>
<td>3 m × 3 m</td>
<td>1</td>
</tr>
</tbody>
</table>

NOTE: Hallway is not inclusive in the sizes
- **Furnitures**

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Desk with lockable drawers, 0.8 m × 1.8 m</td>
</tr>
<tr>
<td>5</td>
<td>Armchair</td>
</tr>
<tr>
<td>2</td>
<td>Desk chair</td>
</tr>
<tr>
<td>2</td>
<td>Table, 1 m × 2 m</td>
</tr>
<tr>
<td>8</td>
<td>Chair</td>
</tr>
<tr>
<td>4</td>
<td>4-drawer metallic cabinet</td>
</tr>
<tr>
<td>1</td>
<td>Desk &amp; chair for the typist</td>
</tr>
<tr>
<td>7</td>
<td>Filing box</td>
</tr>
<tr>
<td>1</td>
<td>Wall-mounted metallic drawer</td>
</tr>
<tr>
<td>4</td>
<td>2-door metallic cupboard</td>
</tr>
<tr>
<td>7</td>
<td>Rubbish bin</td>
</tr>
<tr>
<td>1</td>
<td>Photocopier (w/ 200%~50% zoom) incl. paper box, scanner, etc.</td>
</tr>
<tr>
<td>1</td>
<td>Binder</td>
</tr>
</tbody>
</table>

**NOTE**: Two sets of the keys for the desks, windows, doors, etc. shall be provided.

- **Items for the tea room:**

  Refrigerator, electric stove, electric kettle, five tea cups, sink (including a cupboard and a bench)

- **Items for the restrooms:**

  Toilet paper bars and two sinks shall be provided in each of the two restrooms.

---

**Extra Provisions**

2. **Table of Other Provisions**

- **The followings will be provided:**

<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>55m tape level meter with an embedded water level sensor to measure the depth of the intake tower</td>
</tr>
</tbody>
</table>
6. Architectural Specification

Engineer’s Requests

1.4 Engineer’s Requests

1.4.1 Engineer’s Office

The contractor should provide furnitures and equipment for the engineer’s office.

The office should be located at the center of the location agreed by the engineer.

The office should be fully equipped and furnished prior to construction.

The contractor shall provide and maintain all the temporary services such as gas, electricity, drinking water as requested by the engineer.

A paved parking space large enough for at least six vehicles with four of them being roofed.

The office should be built with approved materials, and protected from weather and insects, sufficiently air-circulated, heat insulated, well-lighted, equipped with safety locks, and painted.

The followings are sizes and numbers of the rooms defined by the engineer.

<table>
<thead>
<tr>
<th>#</th>
<th>Classification</th>
<th>Size</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Residing engineer</td>
<td>4 m × 4 m</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>Residing engineer’s assistant</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>3.</td>
<td>Inspector</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>4.</td>
<td>Surveyor</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>7.</td>
<td>Typist</td>
<td>4 m × 4 m</td>
<td>1</td>
</tr>
<tr>
<td>8.</td>
<td>Meeting room</td>
<td>5 m × 4 m</td>
<td>1</td>
</tr>
<tr>
<td>9.</td>
<td>Storeroom</td>
<td>4 m × 3 m</td>
<td>1</td>
</tr>
<tr>
<td>10.</td>
<td>Kitchen</td>
<td>3 m × 3 m</td>
<td>1</td>
</tr>
</tbody>
</table>

- The two restrooms should be movable and include sinks, toilet paper bars, etc.

The contractor should manage the office and stationaries.

The office, as well as the kitchen and restrooms should be cleaned daily and secured during night.

The ownership of the office is given to the contractor after the contracted period.
1.4.2 Tools & Softwares

- The contractor should provide tools for the engineer's office. The contractor should submit a detailed list to the engineer for an approval prior to placing an order.

The following tools should be included unless otherwise specified by the engineer.

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Desk</td>
</tr>
<tr>
<td>6</td>
<td>Desk with lockable drawers</td>
</tr>
<tr>
<td>6</td>
<td>Armchair</td>
</tr>
<tr>
<td>4</td>
<td>Table (1m × 2m)</td>
</tr>
<tr>
<td>8</td>
<td>Chair</td>
</tr>
<tr>
<td>4</td>
<td>2-door metallic cupboard</td>
</tr>
<tr>
<td>7</td>
<td>Bookshelf in the size of a wall</td>
</tr>
<tr>
<td>7</td>
<td>Filing box</td>
</tr>
<tr>
<td>1</td>
<td>Flip chart paper &amp; marker flip</td>
</tr>
<tr>
<td>8</td>
<td>Waste paper box</td>
</tr>
<tr>
<td>2</td>
<td>Key set</td>
</tr>
<tr>
<td>1</td>
<td>Safety lock device</td>
</tr>
</tbody>
</table>

- The following additional devices should be provided by the contractor:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Photocopyer</td>
</tr>
<tr>
<td>2</td>
<td>Computer w/ MS Office installed &amp; internet connection</td>
</tr>
<tr>
<td>2</td>
<td>Printer (A3 color printer &amp; A4 laser printer)</td>
</tr>
<tr>
<td>1</td>
<td>Scanner</td>
</tr>
<tr>
<td>2</td>
<td>Telephone</td>
</tr>
<tr>
<td>2</td>
<td>Radio (incl. 2 battery charger &amp; 3 spare batteries)</td>
</tr>
<tr>
<td>1</td>
<td>Digital camera</td>
</tr>
<tr>
<td>2</td>
<td>Calculator</td>
</tr>
<tr>
<td>2</td>
<td>Torch</td>
</tr>
<tr>
<td>1</td>
<td>Compass/clinometer</td>
</tr>
</tbody>
</table>

- Safety equipment for the engineer's employees, employer, visitors (safety helmet, safety shoes, protective gloves, protective suits, etc.)

- A water level which a minimum of 30m can be measured is considered appropriate to determine the water level of the hydraulic pressure (intake tower).
6. Architectural Specification

- Safety rope, plump, chalk, hammer for seismic survey (7lb sled hammer, 2lb mass hammer)
- Refrigerator, electric stove, electric kettle, glass, sink including cupboards and bench, kitchen utensils, etc.

1.4.3 Vehicles
The contractor should provide two four-wheel drive vehicles for the engineer to use during the contracted period. The contractor should provide fuels, as well as vehicle insurance (as requested by the engineer). The contractor also should provide maintenance for the vehicles such as repair and spare parts including installation. The ownerships of the vehicles are given to the contractor after the contracted period.

1.4.4 Other Services
The contractor should promptly conduct inspections requested by the engineer and provide all necessary manpower, equipment, materials, acquisition methods. The contractor should provide the services with his own expense.