The Republic of Uganda

MINISTRY OF WATER AND ENVIRONMENT

CIVIL WORKS FOR OFF-FARM IRRIGATION INFRASTRUCTURE AND FACILITIES

Volume 2: Technical Specifications

Proc. Ref. No.: MWE/WRKS/24-25/……/1/2/3

LOT 1	**NORTHERN AND CENTRAL UPPER REGIONS**
LOT 2	**WESTERN AND CENTRAL LOWER REGIONS**
LOT 3	**EASTERN PROVINCE AREA**

Issued on: ……January 2025

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1. GENERAL CLAUSES

1.1 General

Chapters 1, 2, and 3 are particular to the Contract and shall take precedence over Chapters 4, 5, 6, 9 and the 4th Edition of the Civil Engineering Specification for the Water Industry (CESWI) and the CESWI Appendix, which contain standard specification clauses.

Clauses refer to all Parts of the works unless specified otherwise.

1.2 Purpose and Location of the Works

The purpose of the works is to develop Off-farm Irrigation Infrastructure and Facilities across the country for 96 No. sites in three areas and batched in three lots as listed below, with an average of 4 hectares (10 Acres) per possession.

Lot No.	Region(s)	No. of sites
1.	Northern and Central Upper	36
2.	Western and Central Lower	36
3.	Eastern Province Area	24

1) Lot 1 – Scheme Site Location

	District	Sub-county	Scheme Name	coordinates	
				Eastings	Northings
1.1	Amolatar	Etam	Teatoke	179,651	459,042
1.2	Apac	Ibuje T/C	Adaka B	427,843	205,773
1.3	Dokolo	Kwera	Alake	499,497	207,599
1.4	Kwania	Nambieso	Lwala	474,072	202,784
1.5	Oyam	Loro	Abeibuti Cell	243,881	451,090
1.6	Oyam	Loro T/C	Bung Iponga	448,152	249,207
1.7	Oyam	Atura	Odyebo	427,890	232,162
2.1	Omoro	Koro	Koro Angaba	420,239	294,316
2.2	Omoro	Bobi	Ocaga	419,141	292,181
2.3	Omoro	Bobi	Opukomany	420,268	291,608
2.4	Kiryandongo	Masindi Port	Kikaito	398,320	182,675
2.5	Kiryandongo	Mutunda	Nyakagweng	398,057	223,055
2.6	Masindi	Bwijanga	Kikungura	348,961	163,934
2.7	Masindi	Bwijanga	Ntooma	341,540	169,270
2.8	Nakasongola	Kakooge	Kinoni	430,649	127,147
3.1	Buvuma	Buvuma T.C	Meeru	525,679	18,064
3.2	Kayunga	Kayonza	Bwamulamira	478,300	111,700
3.3	Kayunga	Kayunga	Buwungiro	483,118	85,602
3.4	Luweero	Zirobwe	Mpangati	430,649	127,147
3.5	Mityana	Zigoti T.C	Mawundwe	409,296	39,658
3.6	Nakaseke	Semuto	Nvunanwa	413,771	164,970

	District	Sub-county	Scheme Name	coordinates	
				Eastings	Northings
3.7	Wakiso	Masulita T.C	Masulita	430,562	58,803
4.1	Alebtong	Akura	Bedimwolo	515,632	258,333
4.2	Agago	Kotomor	Odokomit	291,143	529,693
4.3	Kitgum	Labong Okwanga	Oget	480,765	372,327
4.4	Lamwo	Palabek Ogili	Lagot Opuk	442,929	294,316
4.5	Lira	Aromo	Tekullu	484,180	420,239
4.6	Pader	Piaula	Omeny Ki Mac	318,881	500,450
4.7	Otuke	Ogor	Opore	546071	287344
5.1	Pakwach	Panyimur	Boro East Central	256,734	318,332
5.2	Madi-okollo	Anyiribu	Panyua	279,554	284,930
5.3	Maracha	Oluffe	Abaa	265,230	357,354
5.4	Moyo	Laropi	Paubo	393,581	374,500
5.5	Nwoya	Loro T/C	Ceke	401,322	264,932
5.6	Nwoya	Alero	Ongai	384,134	303,042
5.7	Nwoya	Anaka	Onyom Til	388,437	284,228

Lot 1 – Scheme Location Map

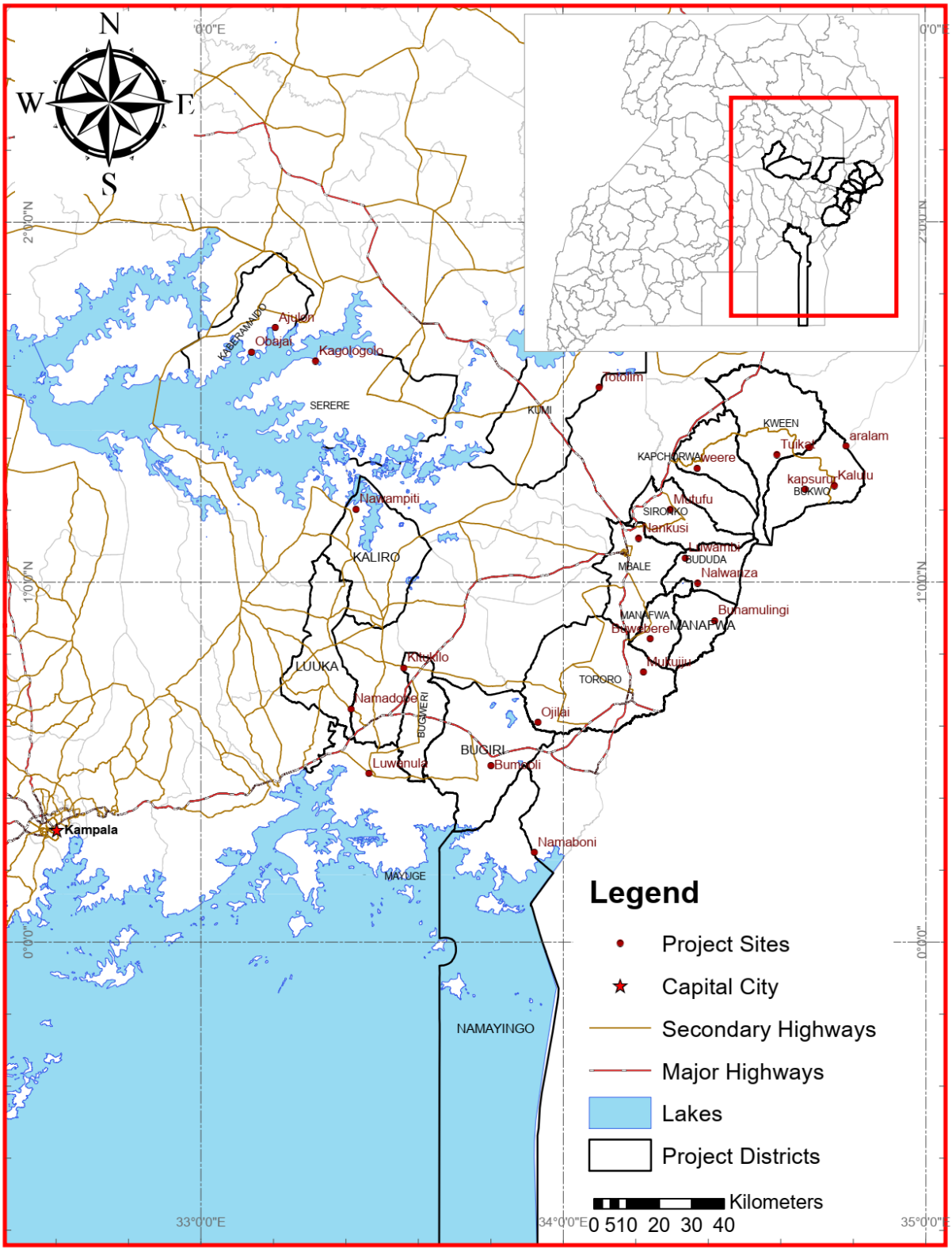
2) Lot 2 – Scheme Site Location

Nr.	District	Sub County	Scheme	Coordinates (WGS 84)	
				Eastings	Northings
1	Buhweju	Burere	Kyakuhanda	201527.02 m E	9952942.15 m S
2	Bukomansimbi	Butenga	Gayaza	341949.39 m E	9979072.65 m S
3	Bunyangabu	Rwimi TC	Kanyamukale	192259.08 m E	44906.64 m N
4	Bushenyi	Nyabubare	Kashozi	174854.00 m E	9943708.00 m S
5	Bushenyi	Kanyabwanga	Rwanshetsya	181221.74 m E	9945849.60 m S
6	Ibanda	Kicuzi	Karuhusi	195,730 m E	9,983,929 m N
7	Isingiro	Isingiro TC	Kikutsi	261966.93 m E	9911896.19 m S
8	Kabale	Kitumba	Kabumba	828240.42 m E	9856832.22 m S
9	Kamwenge	Kamwenge TC	Nyacwamba	216589.89 m E	23429.31 m N
10	Kanungu	Nyamirama	Nyaruhungye	809935.00 m E	9931195.00 m S
11	Kiruhura	Kikatsi	Kikatsi	254337.21 m E	9959265.78 m S
12	Kisoro	Nyakabande	Bugara	804679.00 m E	9861048.33 m S
13	Kyegegwa	Kasule	Bugogo	300723.72 m E	65323.52 m N
14	Kyotera	Kabira	Kakunyu	340173.00 m E	9920207.03 m S
15	Lyantonde	Kinuuka	Rwentamu	293747.11 m E	9970882.47 m S
16	Mitooma	Kanyabwanga	Rwenkurijo	827926.20 m E	9934621.80 m S
17	Ntungamo	Mirama TC	Mirama	215419.16 m E	9884064.22 m S
18	Rakai	Kagamba	Kabusa	315658.97 m E	9926973.91 m S
19	Rubanda	Hamurwa	Nyamasizi	821493.71 m E	9879422.13 m S
20	Rubirizi	Katerea	Katonya	182380.08 m E	9980888.71 m S
21	Rukiga	Kashambya	Kyondo	166531.04 m E	9884977.34 m S
22	Rukungiri	Bugangari	Runkonkoma	816677.75 m E	9916369.37 m S
23	Ssembabule	Mateete	Kanyogoga	343433.79 m E	9967806.27 m S
24	Sheema	Kashozi Division	Rurama	200989.23 m E	9929827.14 m S
25	Bukomansimbi	Bigasa	Kyawamala	354608.00 m E	9996144.00 m S
26	Butambala	Ngando	Ndibulungi	371295.00 m E	4886.00 m N
27	Kagadi	Kyakabindi	Kisigare	258603.00 m E	117235.00 m N
28	Kakumiro	Kitaihuka	Kitaihuka	312910.13 m E	110366.14 m N
29	Kalangala	Mugoye	Nalyamagonja	408990.85 m E	9972257.42 m S
30	Kalungu	Lwabenge	Lwabenge	355525.00 m E	9998114.00 m S
31	Kassanda	Bukuya	Bukuya	370459.17 m E	72083.73 m N
32	Kibaale	Karama	Bucuuhya	285764.65 m E	71665.14 m N
33	Kiboga	Bukomero	Kyomya	383645.00 m E	85267.00 m N
34	Kyankwanzi	Kyankwanzi	Lubiri	359458.04 m E	136464.69 m N
35	Masaka	Kyesiiga	Bugere	354480.00 m E	9939768.00 m S
36	Mpigi	Kituntu	Kawomya	380563.00 m E	4476.00 m N

Lot 2 – Scheme Location Map

3) Lot 3 – Scheme Site Location

No.	District	Subcounty	Scheme Name	coordinates	
				Eastings	Northings
1.1	Bukwo	Kapsarur	Kapsarur	685474.68	138999.7
1.2	Bukwo	Kalulu	Kululu	696200.00	140800.00
1.3	Bukwo	Lwongon	Lwongon	686806.31	151983.99
1.4	Bukwo	Amanang	Kongta-Tulwo	689938.14	138735.35
1.5	Kapchorwa	Kaserem	Weere	661358.62	155561.42
1.6	Kween	Tuikat	Tuikat	676934.15	149802.02
1.7	Sironko	Mutufu	Mutufu	644241.15	133059.64
2.1	Bududa	Nangako	Luwambi	648689.79	117956.02
2.2	Bududa	Nalwanza	Nalwanza	659778.07	106721.28
2.3	Tororo	Ojilai	Iyolwa	609603.22	67090.67
2.4	Tororo	Mukuju	Mukuju	635987.38	83178.60
2.5	Mbale	Namanyonyi	Nankusi	634407.45	123944.17
2.6	Manafwa	Bukobere	Buwebere	637993.10	93211.42
3.1	Kaberamaido	Okile	Obajai	516000.00	180700.00
3.2	Kaberamaido	Aperikira	Ajulon	523081.33	188709.52
3.3	Kumi	Kanapa	Totolim	619094.03	170068.38
3.4	Serere	Bugondo	Kagologolo	535803.95	179638.59
3.5	Bugweri	Namalemba	Kitukilo	562257.00	84147.00
3.6	Mayuge	Imanyiro	Luwanula	551628.16	51714.830
4.1	Iganga	Namungalwe	Namunkanaga	558367.63	81036.34
4.2	Namayingo	Banda T/C	Namaboni	602395.46	27498.98
4.3	Tororo	Kayoro	Buyemba	624250.03	69581.39
4.4	Namayingo	Bukana	habayaga	591344.00	18620.00
4.5	Soroti	Gweri	Gweri	585290.10	189867.40



Lot 3 – Scheme Location Map

1.3 General Description of the Works

The Contract is for the supply of materials, construction of water intake/ abstraction works, laying of pumped and gravity water pipelines and associated civil works, and installation and commissioning solar powered mechanical and electrical plant. The extent of the Works is specified in Chapter 2.

The Works will comprise parts as described below:

1) **Part 1: Water Intake/ Abstraction, Building and Solar Based Mechanical -Electrical Works**

The construction of water diversion channels, river weirs/ pump sumps/ chambers, pump control house and installation of solar PV generator, centrifugal submersible pumps and all associated mechanical and electrical works.

2) **Part 2: Water Supply Pumping and/ or Gravity Transmission Pipe Laying**

Supply and laying of new pipelines and associated fittings and chambers.

3) **Part 3: Reservoirs**

The construction of elevated plastic reservoirs on ground and or steel towers and all associated mechanical works.

4) **Part 4: Water Supply Gravity Distribution Pipe Laying**

Supply and laying of pipelines and associated fittings and chambers.

A brief description of the facilities to be provided under this in the three Parts of the Works is given below.

1.3.1 Part 1 Water Intake/ Abstraction, Building and Solar Based Mechanical - Electrical Works

Part 1 of the Works comprises the construction of: -

(a) reinforced concrete weirs across streams and narrow rivers and reinforced concrete intake sumps/ chambers, or
(b) lined and/ or unlined intake sumps, or
(c) siting and construction of borehole sources intake works,
(d) installation of solar PV array mounted on a raised steel structure, power invertor, and centrifugal submersible pumps encased in a steel stilling tube and all associated mechanical and electrical works.
(e) buildings out of stone masonry substructure, reinforced concrete floor slab, fired clay brickwork/ concrete blockwork, galvanized pre-painted roofing sheets on timber frame, steel plate windows and doors, etc.

1.3.2 Part 2 Water Supply Pumping and/ or Gravity Transmission Pipe Laying

Part 2 of the Works comprises the supply, laying of water pipes, as shown on the Issued Drawings, and will consist of the following items.

- Supply and laying of pipes and fittings.
- Supply and installation of flow meters.
- Supply and installation of washouts, air valves and associated chambers.
- Supply and installation of consumer connections, and service pipes.

Further details of the work to be undertaken are given in Clause 2

1.3.3 Part 3: Reservoirs

Part 3 of the Works comprises the civil, mechanical and electrical works for the water supply works. The details are in the Issued Drawings and summarised as follows: -

- Construction of 4No. x $10m^3$ plastic storage reservoirs supported on 1.0m high plinths or 3.0 or 4.5 or 6.0 or 9.0m steel towers.

Further details of the work are given in clause 2.

1.3.4 Part 4: Water Supply Gravity Distribution Pipe Laying

Part 4 of the Works comprises the supply, laying of water pipes, as shown on the Issued Drawings, and will consist of the following items.

- Supply and laying of pipes and fittings.
- Supply and installation of flow meters.
- Supply and installation of washouts, air valves and associated chambers.
- Supply and installation of consumer connections/ “Farm-Gate Irrigation Water Hydrants” on OD63mm HDPE pipelines.

Further details of the work are given in clause 2.

1.4 Other Contracts

No other contracts are foreseen.

1.5 Design Life

1.5.1 Part 1, 2, 3 & 4

All materials and equipment shall be designed for long life and continuous operation during prolonged periods with a minimum of maintenance and the Contractor may be called upon to demonstrate this for any component either by the service records of similar equipment elsewhere or by records of extensive type tests.

Routine maintenance and repair shall, as far as possible, not require the services of highly skilled personnel.

The materials of construction of the Plant shall be selected, taking into consideration their location and duty, such that the economic life of the Plant is not less than 25 years.

Except for consumable items such as gland packing, carbon brushes etc. which normally require replacement more frequently, no part subject to wear shall have a life from new to replacement or repair of less than three years of continual operation. Where major dismantling is required to replace a part, such life shall be not less than five years.

1.6 Regulations, Standards, Codes and Standard Specifications

The Contractor shall obtain at least one copy of each DIN, ISO, BS, CP or other approved standard and reference work which is referred to in the Specification, and of each other standards which applies to materials which are being supplied to, or workmanship executed on, the Works. These standards and reference works shall be supplied to the Engineer within 90 days of the Engineer's Order to Commence the Works and will be available to the Contractor at all reasonable times.

1.6.1 Parts 1, 2, 3 & 3

Wherever reference is made in the Contract to specific standards and codes to be met by the materials, plant, and other supplies to be furnished, and work performed or tested, the provisions of the latest current edition or revision of the relevant standards and codes in effect shall apply, unless otherwise expressly stated in the contract. Where such standards are national, or relate to a particular country or region, other authoritative standards, which ensure a substantially equal or higher performance than the standards and codes specified will be accepted subject to the Engineer's prior review and written approval. Differences between the standards specified and the proposed alternative standards must be fully described in writing by the Contractor and submitted to the Engineer at least 28 days prior to the date when the Contractor desires the Engineer's approval. In the event that the Engineer determines that such proposed deviations do not ensure equal or higher quality, the Contractor shall comply with the standards specified in the documents.

All standards used will be the current version. A Contractor proposing to use alternative versions of specified standards and codes shall submit the alternative version to the Engineer for approval in accordance with the requirements outlined in the above paragraph.

All materials and workmanship not fully specified herein or covered by an approved standard shall be such kind as is used in first class work and suitable to the climate in the project area. Where the requirements of any such standard specification or regulation conflict with the requirements of this Specification or any item on the Drawings, then the Contractor should refer to the Engineer for clarification before proceeding with that section of the Works.

Materials, installation and testing of pipelines and their associated works shall be in accordance with the Civil Engineering Specification for the Water Industry, 4th Edition.

1.6.2 Part 1

Except where otherwise specified all materials and workmanship shall comply with current national standards provided that these standards are not less stringent than the equivalent German Standards, British Standards or Codes of Practice or provided that they comply with the requirements of the

International Organisation for Standardisation (ISO) or the International Electro-technical Commission (IEC), as appropriate.

The electricity installation shall comply with all relevant statutory regulations and standards current at date of the bid, unless otherwise indicated within this Specification. Electrical installations shall, where relevant, be in accordance with the IEE Regulation for Electrical Installations, 16th Edition.

1.7 Drawings

1.7.1 Parts 1 & 3

The Drawings comprise the following.

- **Issued Drawings**

The Issued Drawings as hereinafter described.

- **Bid Drawings**

The Bid Drawings as hereinafter described.

- **Approved Drawings**

Approved Drawings as hereinafter described. Manufacture of the Plant shall not begin, nor shall erection of the Plant commence, until the appropriate Approved Drawings are available. The Plant shall be manufactured and erected in accordance with the Approved and Engineer's Drawings.

- **Engineer's Drawings**

The drawings issued from time to time by the Engineer.

- **Record Drawings**

Record Drawings as hereinafter described.

- **Other Drawings**

1.7.2 Parts 2 & 4

The Drawings comprise the following:

- **Issued Drawings**

The Issued Drawings as hereinafter described.

- **Approved Drawings**

Approved Drawings as hereinafter described. Installation of pipelines and other works for which

Approved Drawings are required shall not begin until the appropriate Approved Drawings are available. The plant shall be installed in accordance with the Approved and Engineer's Drawings.

- **Engineer's Drawings**

The drawings issued from time to time by the Engineer.

- **Other Drawings**

1.8 Issued Drawings

These are drawings issued to the Contractor with the Bid Documents for the purposes of preparing a bid.

Such drawings shall be deemed to have been issued for the guidance of bidders, and shall be referred to for the interpretation of the Contract only where the drawings supplied by the Contractor at the time of bidding and incorporated in the Contract are insufficient.

1.9 Bid Drawings

The Bid Drawings are supplied by the Contractor for the purpose of illustrating his bid, namely:

- a layout of the whole scheme, scale 1:100; or as indicated thereon
- drawings and technical details of the Plant in sufficient detail to illustrate that the several items of Plant are suitable for their intended purpose.

Where Bid Documents including Bid Drawings show features not in compliance with this Specification, and where such features are not listed in the Technical Schedules then the requirements of the Issued Documents will be taken as the basis of the Contract.

1.10 Approved Drawings

With reference to Sub-Clause 23 of the General Conditions the Contractor shall submit, for approval, each drawing in the following categories and schedule.

1.10.1 Part 1 & 3

- **Plant Drawings – N/A**

These shall be submitted within 5 months of the Commencement Date and shall include but not be limited to:

- general arrangement drawings to illustrate the position of the Plant in relation to the appropriate part of the Works in sufficient detail to show all the principal dimensions, methods of support and other relevant information;

- drawings of the Plant in sufficient detail for the Engineer to satisfy himself that jointly and severally the items of the Plant are suitable for their intended purpose;

- sectional drawings of each major item of the Plant, with a parts list and a list of materials to be used for each part. General arrangement of electrical panels with foundation and cable access details;

- diagrammatic outline and detail drawings of all services to, from and between the several items of the Plant, including potable and process water supplies, pipework, connections and fittings, electrical single line and schematic diagrams, cable schedules and site cable layout, connections and fittings, and drainage pipework and fitting;

- requirements for incoming supplies, services etc. and details of interface connections in respect of the Plant, particularly where such connections are at the limit of Contract;

- details of wastes, effluent discharges, etc. and details of interface connections in respect of the Plant, particularly where such connections are at the limit of Contract;

- detailed drawings of the Plant and data in sufficient detail as may be reasonably required for the Engineer to satisfy himself as to the stability, durability and safety of the works and for ascertaining of inspection of the Plant during construction that it is in conformity with the Contract;

- fully detailed installation drawings giving complete dimensions of pedestals, cuts, chases, bolt holes, ducts and other provisions to be made in the civil structures and on site of fixing the Plant.

1.11 Procedure for Approval of Drawings

Unless otherwise indicated within this Specification preliminary copies of drawings for approval shall be submitted to the Engineer.

Any alterations required by the Engineer to be made to drawings submitted for approval shall be made by the Contractor without extra charge, or extension of time, provided such alterations are not consequential upon a change in the requirements of the Contract.

Drawings when approved will be stamped with the Engineer’s approval stamp and one copy of each such approved drawing will be returned to the Contractor.

Acceptance of Bid Drawings shall not be deemed to confer the Engineer's approval upon them.

1.12 Record Drawings

1.12.1 Part 1, 2, 3 & 4

The Contractor shall provide a set of as built drawings for the works. He shall submit four (4No.) hard copies of the drawings, a soft copy (digital format), a print out of the co-ordinates of the fixtures (e.g., valves, bends, manholes, etc.) and an electronic copy of the co-ordinates. The Contractor shall agree the details of the electronic copies with the Engineer

1.12.2 Part 2 & 3

A coloured and framed drawing showing all valves, pipe runs etc., together with detailed operating

instructions for use in the pumping station and four full sets of Record Drawings will be required by the Employer on the completion of the work. The Drawings and one soft copy (digital format) shall be fully dimensioned, general arrangement and detail drawings together with electrical wiring diagrams. All drawings submitted for approval shall be included in the record drawings. Revised drawings shall be submitted within one month of any amendments made during erection. The record drawings shall be submitted with the operating instruction manuals as specified in Clause 1.21.

1.13 Contractor's Calculations and Technical Details – N/A

Part 1

Within two months of the Commencement Date the Contractor shall submit to the Engineer design calculations and technical details of the Plant and structures further to those accepted with his Bid, in sufficient detail for the Engineer to satisfy himself that the items of the Plant and the structures are jointly and severally suitable for their intended purpose.

The design calculations and technical details shall include design calculations, piping and instrumentation diagrams, hydraulic flow diagrams, technical details and schedules of major plant and structures.

The Contractor shall also provide such additional details and calculations and other data as may be reasonably required by the Engineer to satisfy himself to the stability, durability and safety of the works and for ascertaining and inspection of the plant and structures during construction that it is in conformity with the Contract.

The Contractor shall submit as part of his technical details, the magnitude and frequency of all out of balance forces of the plant to allow them to be taken into account in the structural design of civil and building structures.

1.14 Programme

1.14.1 Parts 1, 2, 3 & 4

In a bid to ease the coordination of the construction, avoid "spreading wide but being thin on ground and avoid stretching the supervision activities, the works in each Lot have been clustered based on travel distances and proximity of the schemes as follows: -

i) Lot 1 – 5 Clusters.
ii) Lot 2 – 5 Clusters.
iii) Lot 3 – 4 Clusters

The Contractor is expected to work within one cluster at a time unless he can demonstrate capacity to work in more than one (1No.) Cluster concurrently. This will require prior agreement with the Engineer.

Before commencing the Works, the Contractor shall, submit to the Engineer for his approval a programme showing the order in which he proposes to carry out the Works. The programme shall be in the form of a bar chart, or any other form as may be agreed by the Engineer, and shall be co-ordinated to take into account transportation and delivery times for the materials and for climatic and other conditions to provide for the completion of the Works in accordance with the Contract. The programme shall clearly indicate the following:

- the sequence of each activity, the proposed start and completion dates of each activity, the rate of progress and the cumulative quantity of percentage of work expected to be achieved on each activity by the end of each month;

- dates by which major drawings requiring the Engineer's approval will be submitted (a period of one (01No.) week shall be allowed from date of receipt of these drawings for such approval);

- the time allocated for work by others, including those of the Employer and by utility undertakings.

Sufficient space should be provided in the programme for recording the actual progress against the programmed progress for each activity.

The programme shall be submitted with details of the following:

- a statement giving the numbers and categories of supervisory and technical staff and skilled and unskilled workers to be employed on the Works;

- a list and type details of major Constructional Plant (including vehicles) which the Contractor proposes to employ on the Works;

- details of the Contractor's methods of working for all operations;

- a statement giving the proposals for location or locations and sizes of accommodation, offices, workshops and stores;

- details of the programme for the Works from the date of receipt of the Engineer's order to commence the Works including a complete resource allocation showing the number of units and allotted times for each unit of Constructional Plant, materials and labour allocated to each part of the Works.

1.15 Progress Meetings and Reports

During the period of the Contract, the Contractor shall allow for all consultations with the Employer and the Engineer and his staff in Project Town, Kampala, or elsewhere as necessary.

From the commencement of the work on Site there will be a series of monthly Site progress meetings to coordinate the civil and plant works. Representatives of the Contractor, approved by the Engineer, shall attend monthly progress meetings on Site or at the offices of the Employer. In addition, approved representatives of the Contractor shall attend further meetings in cases of emergencies or for other reasons when called upon by the Employer.

The Contractor shall submit to the Engineer each month a report on his progress in the performance of the Contract. The report shall include a copy of the approved programme with the current progress for each activity shown.

1.16 Organization of Activities

1.16.1 Parts 1, 2, 3 & 4

The Contractor shall organise his activities within the Contract Area in such a way as to minimise disruption to both the public, to water consumers and his sequence of working shall be clearly indicated in the Programme. The Contractor shall submit a fully detailed programme of work to the Engineer for approval.

1.17 Notice of Operations

The Contractor shall give full and complete written notice of all important operations to the Engineer sufficiently in advance of not less than 48 hours and in a form approved by the Engineer, to enable the Engineer to make such arrangements, as he may consider necessary for inspection or for any other purpose. The Contractor shall not commence any important operation without the written approval of the Engineer.

The Notice of Operation shall be followed by a Request for Inspection/Approval, in a form approved by the Engineer, in which the Contractor shall seek permission for executing any part of the Works.

Important works shall include all operations occurring on the site outside the following hours:

- Monday to Friday: 8:00 am to 5:00 p.m. These shall be the normal site working hours.

1.18 Public Holidays

The Contractor shall allow in his programme for the following 14 public holidays per calendar year as observed in the Republic of Uganda and upon which days the Contractor shall not be permitted to work:

(a) New Year's Day (1st January),

(b) NRM Anniversary Day (26th January),

(c) Janani Luwum Day (16th February),

(d) Eid al-Fitr,

(e) Women's Day (8th March),

(f) Good Friday,

(g) Easter Monday,

(h) Labour Day (1st May),

(i) Martyrs' Day (3rd June),

(j) Heroes' Day (9th June),

(k) Independence Day (9th October),

(l) Eid al-Aduha,

(m) Christmas Day (25th December),

(n) Boxing Day (26th December).

1.19 Site Management

The Contractor shall keep complete and accurate records, using a form approved by the Engineer, of Works and associated activities/events on Site. These records shall include, but are not limited to, details of the Works executed; delivery to Site of Materials, Plant and Contractor's Equipment; removal from Site of any item of Contractor's Equipment and weather conditions.

The Contractor shall prepare monthly progress reports and submit them to the Engineer in three copies. The first report shall cover the period up to the end of the first calendar month following the Commencement Date. Reports shall be submitted monthly thereafter, each within 7 days after the last day of the period to which it relates.

Reporting shall continue until the Contractor has completed all work which is known to be outstanding at the completion date stated in the Taking-Over Certificate for the Works.

Each report shall include

a) Charts and detailed descriptions of progress, including each stage of design (if any), Contractor's Documents, procurement, manufacture, delivery to Site, construction, erection and testing; and including these stages for work by each nominated Subcontractor,

b) Photographs showing the status of manufacture and of progress on the Site;

c) For the manufacture of each main item of Plant and Materials, the name of the manufacturer, manufacture location, percentage progress, and the actual or expected dates of:
    i) commencement of manufacture,
    ii) Contractor's inspections,
    iii) tests, and
    iv) shipment and arrival at the Site;

d) Records of Contractor's Personnel and Equipment;

e) Copies of quality assurance documents, test results and certificates of Materials;

f) Safety statistics, including details of any hazardous incidents and activities relating to environmental aspects and public relations; and

g) Comparisons of actual and planned progress, with details of any events or circumstances which may jeopardise the completion in accordance with the Contract, and the measures being (or to be) adopted to overcome delays.

1.20 Packing and Protection

Before any item is despatched from a manufacturer's factory it shall be adequately protected and packed so as to arrive at the Site intact and undamaged. The Engineer shall be given at least 14 days' notice that packing will commence. The method of protection and packing must be suitable to withstand the conditions, which may be experienced in shipment and delivery to the Site. It should also be suitable to withstand long periods of storage out of doors.

No one crate or package shall contain items of Plant intended for incorporation in more than one

part of the Works.

All items shall be clearly marked for identification against the packing list, which shall be placed in every crate or package and protected in a waterproof envelope.

All crates and packages shall be clearly marked with a waterproof pen and weather-proof material to show the weight and where the weight is bearing, and where the sling should be attached. They shall also be marked to identify the packing lists.

Bright parts and bearing surfaces shall be protected from corrosion by the application of a rust-preventive lacquer, high melting point grease or similar. A sufficient quantity of appropriate solvent shall be supplied with the Plant for the removal of this protection.

Each crate or package shall have a clear indelible and, as far as possible, indestructible unique identification cypher, also quoted on the packing list inside it. Three copies of the packing list shall be posted separately to the Engineer at the time of shipment.

All flanges and mating surfaces shall be protected by means of a wooden template or similar. The bolts for securing this template shall not be secured by the bolts, screws etc., which form part of the final installation.

1.21 Commissioning

The Contractor is required to provide suitable personnel, to be approved by the Engineer, to operate each section of the Works during commissioning, i.e. the setting to work and testing of individual components of the Works or the complete Works. This shall include Tests on Completion as more fully defined in the Standard Specifications. Commencing during the commissioning period the Contractor shall instruct the Employer's staff in the operation and maintenance of each section of the Works as specified in the Standard Specifications.

1.22 Operating Instructions

1.22.1 Part 1, 2, 3 & 4

The Contractor shall provide five sets of instruction manuals for each of the sections of the Works to cover all items of the Plant and process. The manuals shall describe the installation and operation as a whole and give step by step procedures to enable the Employer to carry out any operations likely to be required during the life of the Plant including erection, commissioning, testing, operation, maintenance, dismantling and repairs. The instructions shall include the operation of valves, etc. existing or provided by others where the operation of these items is part of or associated with any aspect of the Plant operation.

The maintenance instructions shall include lubrication charts, testing and replacement procedures to be carried out daily, weekly, monthly and at other intervals to ensure trouble-free operation. Where applicable, fault location charts should be included to facilitate finding the cause of imperfect operation or breakdown.

Sections of the manuals shall be devoted to each size and type of equipment with relevant detailed descriptions of construction, maintenance and operation with lists of parts and procedures for ordering spares.

The Contractor shall supply five sets of manuals and record drawings for each section of the Works to the Engineer two months before starting the tests on completed plant systems. Where appropriate preliminary draft copies of instructions shall be submitted during erection to facilitate erection and testing of equipment prior to Plant commissioning. Two complete sets of manuals shall be submitted to the Engineer for approval including certification of equipment, three months before the final submission described above.

The manuals shall be fully bound and indexed to A4 size with the name of the Employer, Contractor, the Contract number and name of the scheme clearly marked. A collection of manufacturer's descriptive leaflets will not be acceptable as an instruction manual.

1.23 Water and Electricity Supply

1.23.1 Parts 1, 2, 3, & 4

The Contractor shall make his own arrangements for the supply of water and electricity for the purposes of the Works.

In the event of a reservoir or pipeline failing on hydraulic test, the Contractor shall be responsible for disposing of the test water to allow repairs to be carried out, and for costs of any water tankers required for supplying water for subsequent re-tests.

Water and wastewater derived from the construction, testing and completion of the Works shall be disposed of to the satisfaction of the Engineer so as to cause no damage or complaint.

The Contractor shall supply the disconnected water consumers during construction works with potable water. The Contractor can bill for these services as provided for in the Bills of Quantities.

1.24 Contractor's Facilities

The Contractor shall provide all site facilities including offices, workshops, stores, accommodation, washing, sanitation etc. necessary for use by his own staff, for the execution of the Works.

The Contractor shall be responsible for making all arrangements for drainage from his site facilities and shall be responsible for payment of all charges in connection therewith.

1.25 Storage of Plant

1.25.1 Part 2 & 3

The Contractor shall be responsible for and bear all costs of securely storing the Plant and Equipment, both on and off site, in suitable environmental conditions to prevent deterioration of the Plant and Equipment until it is incorporated into the Works. The standard of storage to be provided by the Contractor for the Plant and Equipment shall be as follows.

All electrical Plant and Equipment and moving mechanical Plant and Equipment shall be stored by the Contractor in suitable wind and watertight buildings to be provided by the Contractor at his own expense. The stores shall be dust free and shall be adequately ventilated and heated by the Contractor at his own expense, to prevent condensation and deterioration of the Plant and

Equipment. The heating shall be provided by a thermostatically controlled heating system. The stores shall also be adequately lit. The stores and its services shall be approved by the Engineer. The giving of such approval shall not relieve the Contractor of his liabilities for the safe and proper storage of the Plant and Equipment under the Contract.

All other Plant and Equipment shall be stored by the Contractor in secure compounds to be provided by the Contractor at his own expense. Such Plant and Equipment shall be protected as appropriate to prevent its deterioration while in store.

While the Plant and Equipment is in store the Contractor shall take all necessary precautions to maintain the Plant and Equipment in a serviceable condition and these precautions shall be to the approval of the Engineer. Such minimum precautions shall include, but not be limited to, the measures described below.

- Motors shall be stored under polythene with their heaters energised at all times. Packing strips shall be inserted in the air gaps to prevent rotors from resting on stator cores and bearings shall be removed.

- Circuit breaker panels, motor control centres and switchboards shall be stored under polythene and the heaters shall be energised at all times.

- Oil-filled transformers shall be pressurised with an inert gas.

- All flanges shall be closed off with metal caps and all small openings shall be stopped with plastic plugs or caps.

- All shaft exits from casing and bearing housings shall be sealed with Denso tape moulded into place. All closures shall be taped over and the tape painted with three coats of tretoplast sac to form a complete seal.

- All exposed ferrous non-stainless machined surfaces shall be coated with a bitumen solution.

- Thrust and journal bearings shall be removed from the pump and packed in the pump. Journal bearings shall be stored as a matched pair.

- Plant and Equipment shall be inspected every three months to ensure that the packing is intact and that the Plant has not been contaminated by the ingress of moisture.

- The Plant and Equipment shall be examined every six months and desiccants replaced. All rolling elements of Plant and Equipment shall be given 1.25 turns at each inspection.

Notwithstanding the above requirements, the Contractor shall be liable for the safe and proper storage of all Plant and Equipment under the Contract.

1.26 Level Datum

Before the commencement of Construction Work, the Contractor shall establish, in a position to the approval of the Engineer, a benchmark comprising of steel datum pegs which shall be securely concreted in. the level of these pegs shall be established and agreed upon with the Engineer and all levels used in the construction of the Works shall be referred to these established datum points. The

Correctness of this datum shall be checked at regular intervals during the construction period as agreed with the Engineer.

Construction Drawings and all levels used for construction shall be referred to the national height datum as defined by the Survey Department of Uganda. The Contractor shall be responsible for obtaining the location and values of the permanent benchmarks. In cases where such benchmarks do not exist, the site datum shall be agreed upon with the Engineer.

1.27 Climatic Data and Location Level

The Bidder shall verify on his own, the climatic conditions at the site of the Works with the Uganda National Meteorological Authority and take account of the conditions in the design and selection of plant and equipment and make his Work Plan accordingly.

1.28 Contamination of Water Supplies

Before any person is engaged on work involving a risk to the purity of potable water supplies or deemed to involve such a risk by the Engineer, he shall be tested to indicate that he is not a carrier of typhoid or other water-borne disease and he shall be informed of the dangers of contamination. The Contractor shall notify the Engineer of any person who has been certified by a doctor as suffering from an illness associated with looseness of the bowels, and no such person shall be employed on such work until the Employer's medical adviser is satisfied that it is safe for him to be so employed.

The Contractor shall comply with the provisions of `Safeguards to be Adopted in the Operation and Management of Waterworks published by HMSO (UK).

1.29 Site Access and Boundary

It is the Contractor’s responsibility to make provision for any additional accommodation, any special or temporary way leave, or any tip for the disposal of surplus materials, or any borrow pit or quarry required by him outside the Working Areas to carry out the Works.

For the purposes of this Clause, ‘accommodation’ shall be deemed to include housing, offices including office accommodation for the Engineer, workshops, warehouses, and storage areas.

In the event of the Contractor making use of any special or temporary wayleave or additional accommodation required by him or any tip for the disposal of surplus materials, or any borrow pit or quarry, he shall obtain the written consent of the owner, occupier or authority having charge of the land in which such way leave, accommodation or tip is situated and shall make a record agreed by the owner, occupier or authority as aforesaid of the condition of the surface of that land before entering thereon.

The Contractor shall permit the Engineer and any person authorised by the Engineer access for the purposes of the Contract to any such special or temporary way leave or additional accommodation.

In the event of the Contractor making use of any special or temporary way leave or additional accommodation made available to him for the purpose of the Contract, the land in which such wayleave or accommodation is situated shall be deemed to be part of the Site.

The extent of the site is indicated below. The Contractor shall not use the site for any purpose not required by the Contract.

1.29.1 Parts 1 & 4

The site generally comprises Working Areas in fields/ farmlands and along community road where the various Works are to be constructed. Working Area boundaries will be as directed by the Engineer and will generally compose:-

i) a 1.5 metres corridor along the pipeline centreline under the Contract.
ii) a 2.0 metres band beyond the fenced off areas indicated on the Intake, Pump Station and Reservoir Drawings.

1.29.2 Parts 2 & 3

Access to the Site will be as follows:

Using the community road and village paths. No New Site Roads shall be constructed.

The Contractor shall be deemed to have ascertained the site locations to facilitate execution of the works scope.

The Contractor shall execute the Works in such manner as to minimise interruption and interference with the operation of the existing facilities. Access to the existing facilities shall be maintained to the satisfaction of the Engineer at all times.

The Contractor shall apply to the Engineer in writing at least 14 days before starting any work which involves interference with existing structures, equipment, etc. or otherwise interferes with or interrupts the Employer's normal operation. The Contractor shall not execute such work until he has received permission to proceed in writing from the Engineer.

1.30 Use of Public Highways and Roads

The Contractor shall ensure that roads and thoroughfares used by him in any way are not damaged as a result of such use and in the event of their becoming thus damaged in the opinion of the Engineer, the Contractor shall take all necessary steps to remedy/repair them, at no extra cost to the Employer. The Contractor shall obtain all permits required for carrying out the Works on public roads and shall liaise with the appropriate authorities with regard to the timing and execution of the road works.

The Contractor shall be responsible for establishing and maintaining temporary road diversions for the duration of the roadwork. The road shall be kept open at all times during the road works period, and the work shall be carried out in such a manner as to minimise the disruption to traffic.

1.31 Private Property

The Contractor shall make a record, to be agreed by the Engineer, of the condition of the surfaces of any private property, private lands or of any public cultivated or maintained lands over which access to the Site lies before any work is commenced, to make them suitable 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 existing before his first entry on them.

The Contractor shall not first enter any part of the Site in private lands without the prior permission of the Engineer and without first having obtained the consent of the owner of such lands. The Contractor shall give a minimum of two weeks' notice to the Engineer of his intention to begin works in any area.

The Contractor shall provide and maintain at all times, vehicular and pedestrian access to all properties, private and public, to the satisfaction of the Engineer, and not impede access to any properties.

1.32 Clearance of the Site

The Contractor shall clear the Site to the extent required by the Engineer for checking the setting out. Clearance of the Site shall also include the demolition and removal of all articles, objects and obstructions, which are expressly required to be cleared. The Contractor shall not clear the Site of any structure without the prior written permission of the Engineer. The Contractor shall remove the material arising from such clearance and dispose of it in a manner and at a location, on or off the Site, to the approval of the Engineer.

The Contractor shall fill and make good with appropriate materials those cavities and losses of soil, which result from clearing the parts of the Site not subsequently to be occupied by the Permanent Works.

1.33 Condition of the Site

The Contractor shall maintain the Site in a clean, tidy and healthy condition for the whole of such time as he is responsible for the care of the Works.

The Works shall be kept in a dry state and any water entering the Works from any source shall be collected and discharged in a safe manner approved by the Engineer.

1.34 Access for the Employer and Engineer

The Contractor shall permit the Employer and the Engineer and any person authorised by the Employer or the Engineer, including workmen of the Employer, other contractors or utility undertakings, access for the purposes of the Contract, or performing their normal duties, to all areas of the Site and to any additional accommodation or temporary wayleave for the duration of the contract period.

1.35 Noise

The background sound level at any point along the boundary of the Site or Working Areas, arising from the operation of any mechanical equipment, with the exception of the diesel generators, shall not exceed 70 dB (A). The background sound level at any point along the boundary of the Site, arising from the operation of the diesel generators for standby generation shall not exceed 80 dB (A).

No item of Plant and Equipment, shall produce a sound pressure level exceeding 85 dB(A) when measured at a distance of 1 m from the reference surface of that item requirement of ISO 3746

`Acoustic Determination of Sound Power Levels of Noise Services - Survey Methods' or the equivalent ANSI SI.36.

Sound pressure levels shall be measured in dB (A), using a calibrated sound meter meeting the requirements of BS 5969 with the responses speed set to `slow'. The background noise level shall be at least 10 dB (A) below the operating noise level of the machine or other item of Plant and Equipment.

The Contractor shall produce certified evidence from the manufacturer that the appropriate tests have been carried out on all items of the same type which is in all relevant respects similar to the item to be supplied. Such relevant respects would include the running speeds, the power input under the loading conditions which would produce the most noise, the power input under normal operating conditions (if different from the foregoing), the number of stages (for rotary machines) or the number of cylinders (for reciprocating machines).

If an item in its standard build does not comply with the above requirement, the Contractor shall be required to reduce the sound pressure level by providing improved or additional silencers or fitting sound insulating materials to the item.

1.36 Temporary Works

The Contractor shall submit to the Engineer for approval full details of his proposals for temporary works at the Site, at least 14 days prior to the intended start of such work.

The Contractor shall not proceed with such work until he has received the Engineer’s written approval of his proposals for the temporary works. Such approval shall not relieve the Contractor of his obligations and liabilities under the Contract.

1.37 Latrines

Throughout the period of construction of the Works the Contractor shall provide, maintain and clean suitable and sufficient latrines for use by his employees. He shall ensure that his employees do not foul the site but make proper use of the latrines. Cost for the provision and maintenance thereof shall be included in the Contract Price.

Where practicable the latrines shall be connected to the nearest sewer, or if this is not practicable the Contractor shall provide an adequately sized septic tank and soak away or alternative approved by the Engineer.

1.38 Photographs

The Contractor shall supply digital copies of photographs and un-mounted positive prints of not less than 250 x 200 mm of such portions of the Works, in progress and completed, as may be directed by the Engineer and specified herein. The digital copies and prints shall not be altered. The digital copies shall be the property of the Employer and shall be delivered to the Engineer with the prints. No prints or digital copies shall be supplied to any other person without the written permission of the Engineer.

If so directed by the Engineer, the Contractor shall supply transparencies and colour prints in lieu of colour digital copies and prints.

The photographs shall be in two categories:

(i) Progress photographs taken every two days and submitted on a monthly basis for all work aspects.
(ii) Progress **aerial photographs** taken monthly and submitted at every month's end for all work aspects.
(iii) Record photographs taken at completion and supplied at the time of substantial completion and commissioning of the works.

Both categories of photographs shall be properly referenced to the approval of the Engineer and on the back of each print shall be recorded the date of the photograph, the direction in which the camera was facing, an identifying description of the subject and the reference.

Photographs taken for record purposes as ordered by the Engineer or as specified herein shall be supplied with three prints, having the reverse of one subscribed with the signatures of the Contractor and the Engineer (or their authorised representatives) for the purpose of attestation. If required, the Contractor may at his own expense have an additional print similarly attested for his retention.

The Contractor shall supply three CDs / DVDs (or Emailed where agreed upon with the Engineer) containing the digital copies and three prints of each progress/record photograph ordered by the Engineer. He shall supply two additional prints of progress/record photographs selected by the Engineer for incorporation in albums. He shall supply two sets of albums, mount the prints, and title the prints and albums all to the approval of the Engineer.

The taking of photographs of the Works by the Contractor for any other purpose whether for use in Uganda or in any other country shall not be carried out without written approval from the Engineer.

The cost of taking, developing and supplying the photos shall be borne by the Contractor and should be incorporated in the rate for the preparation of as-built drawings.

1.39 Setting out

The Client has carried out preliminary surveys of the pipelines and other hydraulic structures. The Contractor shall carry out a confirmatory survey of the pipelines including capturing and marking the individual boundaries of the beneficiaries farmland, other hydraulic structures. He shall submit survey results to the Engineer who shall assess, inspect, and advise on the need for Contractor redesign with no additional costs to the client. Any design revisions shall be deemed to have been captured in the Contract under the As – built Drawings.

The Site Layout Drawings show indicative Site Layouts. Before commencing construction, the Engineer will agree with the Contractor on the basic information supplementary to that shown on the Drawings such as the position of manholes, chambers, centrelines, and baselines sufficient for the Contractor to locate the Works.

The Contractor shall prepare detailed Setting Out Drawings and Data Sheets as necessary and submit them to the Engineer in triplicate for approval. Any modifications to the Setting Out Drawings or Data Sheets required by the Engineer shall be made by the Contractor and resubmitted for final approval. Should it be necessary during setting out or during construction for the approved setting out details to be amended, the Contractor shall amend the Drawings or Data Sheets or make

new ones for approval as required by the Engineer.

For water pipelines, sewers, etc. the Contractor shall in the presence of the Engineer set- out the pipeline alignments following the indicative alignments shown on the drawings taking into account physical features on the ground, any existing services, any requirements of relevant Authorities and any changes deemed necessary by the Engineer, confirming the locations of all valves, air valves, washouts, hydrants, bends, manholes, etc.

The Contractor shall prepare and submit to the Engineer, at an approved scale, Plans of the Water / Sewer line Pipeline Routes and profiles of ground levels after any initial clearing of the wayleave or easement showing the proposed pipe invert levels and precise chainages for all valves, fittings, manholes, etc. for approval. Following approval, the Contractor shall submit to the Engineer two copies of the agreed alignment and profiles.

The Contractor shall also be required to carry out a Site / Engineering Survey of demarcated land where permanent structures/appurtenances will be constructed as directed by the Engineer after initial clearance of sites. The Contractor shall prepare an updated layout plan with contours at 1.0m intervals. The contours shall be generated from a 10x10m grid topo survey.

Final horizontal and vertical alignment of all pipelines shall be agreed with the Engineer prior to the commencement of works as detailed in Chapter 3 of this Specification. The sitting of the pump houses shown on the Scheme Layouts are schematic. The final positions will be agreed upon with the Engineer.

1.40 Units of Measurement

All designs, drawings, specifications and manuals shall use SI (kg, m, s) units and all measurements, dimensions and performance data shall be quoted in those units.

1.41 Languages

All drawings, instructions, signs, notices, name-plates etc. for use in the operation and maintenance of the completed works shall be in English.

Warning signs shall be in English. However, where deep excavations and water points occur, the warning signs shall comprise in three languages of English and Kiswahili and another Local language widely spoken in the area.

1.42 Contract Signboard

The Contractor shall supply and erect two (2No.) Contract Signboards at each location of the works scope as directed by the Engineer. The signboards shall be of substantial construction as detailed in the Drawings and to the approval of the Engineer and the lettering shall be black on a white background. The layout and dimensions of the signboards shall be approved by the Engineer. The sign boards must be erected not later than four weeks after contract commencement.

1.43 Advertising

The Contractor shall not use any part of the Site for any form of advertising without the prior written approval of the Engineer.

1.44 (a) Safety & Health Regulations on Site

The Contractor shall comply with all statutory and other regulations concerning the safety of his site staff, operatives, staff of the Employer and Engineer and members of the public, as a result of his operations. He shall obtain copies of all regulations and shall make them available on Site for inspection by the Engineer.

Notwithstanding the above the Contractor shall ensure that the following primary site safety rules are adhered to at all times.

- All open excavations shall be fenced off with temporary fencing at all times and shall be adequately lit at night.

- Excavating and earthmoving plant and equipment must not encroach on live carriageways at any time. The Contractor shall ensure that all items of plant working adjacent to live carriageways are accompanied by a Banksman at all times.

- Construction materials, bedding material and excavated material stored adjacent to the pipe trench must be safely and securely stored, and must not encroach onto the live carriageways, pedestrian footpaths, private or public access ways or watercourses, unless prior approval is given by the Engineer.

- Provision of sanitary accommodation and PPE including orientation of workers on use of equipment.

1.45 (b) Occupational Health and Safety Risks

- The Contractor shall prepare and implement an occupational safety and health plan for all sites, approved by the developer.

- The Contractor shall provide safety guidelines to all operations prior to start of work.

- Strict adherence to safety measures and procedures are required to minimize (or eliminate) risks of accidents or hazardous developments occurring and ensure healthy and safe conditions for all persons working on the site. To ensure occupational health and safety on construction sites, the Contractor shall be obliged to comply with all applicable Ugandan construction Health and Safety Standards as required by the Occupational Safety and Health Act of 2006. These include provisions of the Factories Act, Labour Unions Act and Workman's Compensation Act.

- Training will be conducted on how to prevent and manage incidences. This should involve proper handling of electricity, water etc. and sensitization on various modes of escape, conduct and responsibility during such incidences. All must fully be aware and mentally prepared for potential emergency.

- Regular drills will be constantly followed on various possible incidences. This will test the response of the involved stakeholders. Such drills will keep them alert and they will become more responsive in case of incidences.

- Personnel on duty shall at all times wear appropriate PPE, such as safety glasses with side shields, face shields, hard hats/helmets, and safety boots be required for all site staff.
- The Contractor shall establish emergency entrances, exits and amenities.
- The Contractor shall ensure access to first aid kits.
- The Contractor shall ensure safe working heights through provision of work platforms, scaffolds and adequate supervision by ensuring regular inspection of formwork, false work and temporary supports before loading or pouring concrete.
- The Contractor shall secure site boundaries with fences or hoardings as appropriate.
- The Contractor shall install caution signage around the site to discourage the public from being close to the site, for example, “falling debris”, “keep off the site” etc.
- The Developer through the Construction Supervisor will continually monitor Contractors´ compliance with Health and Safety measures.
- An Accident Log will be maintained onsite to register all injuries and to investigate their causes during both the construction and operation phases of the project.
- The manufacturer's instructions and Material Safety Data Sheets (MSDS) shall be followed for the storage of all chemicals used in water treatment. Storage must conform to compatibility restrictions.
- Work force shall be subjected only to standard work shifts/hours. Overtime allowances, if applicable/warranted shall be paid with ceiling limits. Working beyond such ceiling limits shall be discouraged, even if, so desired workforce or contractor.

1.46 Protection of Existing Public and Private Services

The Contractor shall notify all public authorities, utility companies and private owners of proposed works, which will affect them not less than one week before commencing the Works.

The Contractor shall adequately protect, uphold, maintain and prevent damage to all services and shall not interfere with their operation without the prior consent of the public authorities, utilities, utility companies, private owners, or the Engineer as appropriate.

If any damage to services results from the execution of the Works, the Contractor shall immediately carry out the following:

- Notify the Engineer and appropriate public authority, utility company or private owner.
- Make arrangements for the damage to be made good without delay to the satisfaction of the public authorities, utility company or private owner as appropriate. The Contractor shall be liable for all costs for making good such damage.

The Engineer may issue instructions or make other such arrangements, as he deems necessary, to

repair rapidly any essential services damaged during the execution of the Contract. Such arrangements shall not affect any liability to pay for making good the damage.

1.47 Permits

The Contractor shall be fully responsible for obtaining all necessary permits, licences and permissions required for the execution of the Works, prior to the commencement of the Works. Payment for the permits should be included in the contractor's respective rates.

1.48 Insurance

The Contractor is required to maintain insurance for the Works in accordance with the Conditions of Contract, including insurance of all pipework, fixtures, fittings, valves and meters etc. supplied by others, for which the Contractor is solely responsible. In addition, the Contractor is required to maintain the value of his insurance cover and Performance Security in respect of the rise and fall of costs, in accordance with the Conditions of Contract.

1.49 Environmental Protection

The Contractor shall enforce environmental mitigation measures, as listed below. However, the Contractor shall not be limited to the listed mitigation measures.

Table 1-1 Mitigation Measures and Preliminary Environmental Management Plan during Construction of Water Supply System.

Construction Period		
Project Impact	**Mitigation Measure**	**Responsible Party**
General		
Soil degradation	Top soil should be stockpiled up separately from subsoil. After completion of work the top soil should be spread over those areas, which can be partially restored in order to facilitate natural regeneration of those areas	Contractor
Soil erosion	The enhanced erosion potential of the soil especially in areas with high relief energy induced by excavation activities may be reduced by sowing of grass. Extremely steep hillsides have to be protected by technical measures.	Contractor
Soil compaction	Restriction of the construction work to the construction area (minimising of space consumed);	Contractor
Excavation	Excavation material should be reused for re-filling of trenches or landscaping of all sites as far as possible.	Contractor
Clearance of vegetation	Protection of trees and roots, if damage to trees is unavoidable replanting of trees is required	Contractor
Loss of harvest	may be reduced to a certain extent by an appropriate activity schedule which takes into account the main harvest time. Compensation by cash	Contractor MWE

Construction Period		
Project Impact	**Mitigation Measure**	**Responsible Party**
Dust generation (health)	During dry seasons moistening of excavation sites upon requirement, cover of haul trucks carrying excavation material	Contractor
Employment opportunities	Utilisation of local labour resources	Contractor
Security, health and safety of workers and the public	Provide warning signage where needed Provide information to the public Fencing and watchmen where needed First Aid and HIV/ AIDS clinic maintained on the main site compound Educating and sensitising the workforce on communicable diseases such as cholera, STDs and HIV/AIDS and provision of Condoms to the workforce.	Contractor
Material Sourcing	Liaison with local authorities to only source materials from legally registered suppliers	Contractor
Siltation of aquatic habitant s	Drain sites adequately and direct surface run off appropriately to avoid water logging of adjacent area	Contractor
Air Quality	Provide adequate and appropriate personal protective equipment (PPE) and air quality monitoring. Dust suppression, observe 30km/hr and covering of construction materials in transit	Contractor
Public Health	Creation of awareness, provision of waste bins and health care	Contractor
Noise	Provide PPE and other measures to reduce on the noise within the site	Contractor
Surface water pollution	Treat wastewater before disposing it to the environment or to soak way or soak pit	Contractor
Site specific for Pipeline network		
Traffic congestions	Proper scheduling, planning of short-term deviations of traffic where necessary to avoid bottlenecks to the maximum extent feasible. Traffic control and safety signals and lighting should be in accordance with national and local regulations. Safe detours and walkways for pedestrians shall be implemented as necessary.	Contractor
Permanent loss of agricultural land	Compensation	Contractor MWE

2. GENERAL REQUIREMENTS OF THE WORKS

2.1 Lot 1 - Northern and Central Upper Regions.

The summary of scope of works for the Thirty-six (36) off-farm irrigation scheme Infrastructure and Facilities. Full details are in Bills of quantities.

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		Elevated Tanks x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
NORTHERN AND UPPER CENTRAL REGIONS																		
1.1	Teatoke	N	Amolatar	L. Kwania	3	20	100	11	15	2*17	34	18.7	90/16	430	30m^3 steel tank on 6m	90/16	285	12
																75/16	380	
1.2	Adak B	N	Apac	R. Nile Swamp	1	20	55	7.5	11	2*17	34	18.7	90/10	370	30m^3 steel tank on 6m	90/6	406	5
																75/6	140	
																63/6	260	
1.3	Alake	N	Dokolo	L. Kwania Swamp	1	20	70	7.5	11	2*17	34	18.7	75/16	325	30m^3 steel tank on 6m	90/6	364	5
																63/6	396	
1.4	Lwala	N	Kwania	L. Kwania Swamp	1	20	100	11	15	2*17	34	18.7	90/16	332	30m^3 steel tank on 6m	75/6	288	5
																63/6	285	
1.5	Abeibuti	N	Oyam	Okole Swamp	1	20	70	7.5	11	2*17	34	18.7	75/16	420	30m^3 steel tank on 6m	90/10	285	5
																63/10	360	
1.6	Bung Iponga	N	Oyam	Iponga Swamp	1	20	70	7.5	11	2*17	34	18.7	75/16	340	30m^3 steel tank on 6m	90/6	235	5
																75/6	192	
																63/6	462	
1.7	Odyebo	N	Oyam	R. Nile Swamp	1	20	100	11	15	2*17	34	18.7	90/16	330	30m^3 steel tank on 6m	90/6	387	5
																63/6	120	
2.1	Koro Angala	N	Omoro	R. Tochi Swamp	3	20	100	11	15	2*17	34	18.7	90/16	545	30m^3 steel tank on 6m	75/6	335	5
																63/6	200	
2.2	Ocaga	N	Omoro	Ocaga V.Tank	4	20	70	7.5	11	2*17	34	18.7	90/16	496	30m^3 steel tank on 6m	75/6	298	4
																63/6	225	
2.3	Opukomony	N	Omoro	R. Tochi Swamp	3	20	70	11	15	2*17	34	18.7	90/16	490	30m^3 steel tank on 6m	75/6	460	5
																63/6	80	

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		Elevated Tanks x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
NORTHERN AND UPPER CENTRAL REGIONS																		
2.4	Kikaito	UC	Kiryandongo	R. Nile Swamp	1	20	55	7.5	11	2*17	34	18.7	75/10	330	40m^3 plastic tanks x 6m	90/10	92	21
																75/10	60	
																63/10	687	
2.5	Nyakagweng	UC	Kiryandongo	R. Nile Swamp	1	20	55	7.5	11	2*17	34	18.7	75/10	445	40m^3 plastic tanks x 6m	90/6	195	3
																63/6	80	
2.6	Kikungura	UC	Masindi	R. Ntooma Swamp	5	15	55	4	5.5	1*17	17	9.35	75/10	415	40m^3 plastic tanks x 6m	75/10	582	6
																63/10	100	
																75/6	560	
2.7	Ntooma/ Kyabukule	UC	Masindi	R. Wamala Swamp	1	20	55	7.5	11	2*17	34	18.7	75/10	475	40m^3 plastic tanks x 6m	90/10	230	5
																63/10	198	
2.8	Kinoni	UC	Nakasongola	R. Lugogo Swamp	1	20	55	7.5	11	2*17	34	18.7	90/10	680	40m^3 plastic tanks x 6m	90/6	470	13
																63/6	525	
3.1	Meeru	UC	Buvuma	L. Victoria	3	15	55	4	5.5	1*17	17	9.35	75/10	415	40m^3 plastic tanks x 4.5m	90/6	280	5
																63/6	151	
3.2	Bwamulamira/ Mitigi	UC	Kayunga	R. Sezibwa Swamp	5	20	55	7.5	11	2*17	34	18.7	75/10	400	40m^3 plastic tanks x 6m	110/6	280	5
																90/6	195	
																63/6	86	
3.3	Buwungiro	UC	Kayunga	R. Sezibwa Swamp	1	20	55	7.5	11	2*17	34	18.7	75/10	290	40m^3 plastic tanks x 6m	110/6	167	15
																90/6	248	
																75/6	108	
																63/6	235	
3.4	Mpangati	UC	Luwero	Ponds near Natyaba Stream	4	20	55	7.5	11	2*17	34	18.7	90/10	1,263	40m^3 plastic tanks x 4.5m	90/6	510	4
																63/6	510	
3.5	Mawundwe	UC	Mityana	V. Tank	4	15	160	11	15	2*17	34	18.7	90/10	1,248	40m^3 plastic tanks x 6m	75/6	943	5
																63/6	684	
3.6	Nvunanwa	UC	Nakaseke	R. Mayanja	3	15	100	7.5	11	2*17	34	18.7	75/16	1,100	40m^3 plastic tanks x 4.5m	90/6	425	5
																75/6	240	
																63/6	78	
3.7	Masulita	UC	Wakiso	Swamp	1	15	70	5.5	7.5	1*17	17	9.35	75/10	2,234		75/6	1,490	6

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		Elevated Tanks x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
NORTHERN AND UPPER CENTRAL REGIONS																		
															40m^3 plastic tanks x 4.5m	75/6	195	
4.1	Bedimwolo	N	Alebtong	R. Echonga	5	20	100	11	15	2*17	34	18.7	90/16	332	30m^3 steel tank on 6m	90/6	275	5
																75/6	132	
																63/6	85	
4.2	Odokomit	N	Agago	Odokomit V.Tank	5	25	70	11	15	2*17	34	17.6	75/16	300	30m^3 steel tank on 6m	90/6	227	5
																63/6	93	
4.3	Oget	N	Kitgum	Odel V. Tank	5	25	100	11	15	2*17	34	17.6	75/16	240	30m^3 steel tank on 6m	90/6	200	5
																63/6	300	
4.4	Lagot Opuk	N	Lamwo	Lalee V. Dam	3	25	100	11	15	2*17	34	17.6	90/16	410	30m^3 steel tank on 6m	90/6	300	5
																63/6	166	
4.5	Tekullu	N	Lira	R. Achake	3	20	100	11	15	2*17	34	18.7	90/16	420	30m^3 steel. on 6m	90/6	122	5
																75/6	135	
																63/6	110	
4.6	Omeny Ki Mac	N	Pader	R. Pijoa	1	15	100	7.2	11	2*17	34	18.7	75/16	450	30m^3 steel tank on 6m	90/6	320	5
																75/6	215	
																63/6	235	
4.7	Opore	N	Otuke	Opore Swamp	5	21	60	5.5	11	2*17	34	18.7	90/16	1,060	30m^3 steel. on 6m	50/6	400	5
5.1	Boro East Central	N	Pakwach	R. Nile Swamp	1	20	100	11	15	2*17	34	18.7	75/16	500	30m^3 steel. on 6m	90/6	280	5
																63/6	378	
5.2	Panyua	N	Madi – Okollo	R. Ola	3	20	70	7.5	11	2*17	34	18.7	75/16	340	30m^3 steel. on 6m	90/6	125	5
																75/6	270	
																63/6	867	
5.3	Abaa	N	Maracha	R. Ollufe	5	20	100	11	15	2*17	34	18.7	75/16	240	30m^3 steel. on 6m	75/6	200	5
																63/6	236	
5.4	Paubo/ Paubu	N	Moyo	R. Nile Swamp	1	20	70	7.5	11	2*17	34	18.7	75/16	330	30m^3 steel. on 6m	75/10	200	5
																63/10	165	
5.5	Ceke	N	Nwoya	R. Adibuk	3	22	55	7.5	11	2*17	34	18.7	75/16	300	30m^3 steel. on 6m	90/6	205	5
																75/6	200	

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		Elevated Tanks x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
NORTHERN AND UPPER CENTRAL REGIONS																		
5.6	Ongai	N	Nwoya	R. Ongai	2	20	70	7.5	11	2*17	34	18.7	75/16	450	$30m^3$ steel. on 6m	90/6	225	5
																63/6	1050	
5.7	Onyom Til	N	Nwoya	R. Lamoke	1	22	55	7.5	11	2*17	34	17.6	75/16	530	$30m^3$ steel. on 6m	90/6	20	2
																75/6	250	
																63/6	378	

In addition to the above works, the following are inclusive of scheme works as maybe stated in the Bills of Quantities

- Excavation and Earth works within each scheme.
- Provision of Pump house for all pumped systems
- Provision of chain link fence around the abstraction site and pump house.

2.2 Lot 2 - Western and Central Lower Regions

The summary of scope of works for the Thirty-six (36No.) Irrigation Schemes. Full details are in Bills of Quantities.

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		No. of $10m^3$ Elevated Plastic Tank x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
WESTERN AND LOWER CENTRAL REGIONS																		
1.1	Bugogo	W	Kyegegwa	Small Stream	1	22	55	7.5	11	2*17	34	18.7	75/10	280	4No. x 9m	75/10	103	4
																63/10	182	
1.2	Kisigare	LC	Kagadi	Small Stream	2	20	100	11	15	2*17	34	18.7	75/10	250	4No. x Ground	90/10	210	4
																75/10	60	
																63/10	200	
1.3	Kitaihuka	LC	Kakumiro	Swamp	1	20	75	7.5	11	2*17	34	18.7	90/10	420	4No. x 4.5m	90/10	142	8
																75/10	100	
																63/10	278	
1.4	Bukuya	LC	Kasanda	Kawansenyi Stream	5	20	55	7.5	11	2*17	34	18.7	75/10	646	4No. x 6m	90/10	245	12
																75/10	230	
																63/10	134	
1.5	Buchuya	LC	Kibale	R. Mizizi	3	20	100	11	15	2*17	34	18.7	90/10	640	4No. x 6m	90/10	96	2
																63/10	30	
1.6	Kyomya	LC	Kiboga	R. Mutukula (Stream)	2a	15	75	5.5	7.5	1*17	17	9.35	75/10	644	4No. x 4.5m	90/10	440	12
																75/10	340	
																63/10	720	
1.7	Lubiri/ Rubiri	LC	Kyankwanzi	V. Dam	4	20	100	11	15	1*17	34	18.7	75/10	1,200	4No. x 6m	75/10	200	3
																63/10	158	
2.1	Kakunyu	W	Kyotera	Swamp	1	15	55	4	5.5	1*17	17	9.35	75/10	350	4No. x 4.5m	90/10	55	12
																75/10	175	
																63/10	420	
2.2	Kabusa	W	Rakai	L. Kijanebalola Swamp	1	15	55	4	5.5	1*17	17	9.35	75/10	590	4No. x 9m	75/10	308	3
																63/10	90	
2.3	Ndibulungi	LC	Butambala		1	20	55	7.5	11	2*17	34	18.7	75/10	621		75/10	480	4

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		No. of $10m^3$ Elevated Plastic Tank x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
WESTERN AND LOWER CENTRAL REGIONS																		
				Swamp on R. Katonga System											4No. x 6m	63/10	380	
2.4	Lwabenge	LC	Kalungu	Nabajuzi Swamp	1	20	75	7.5	11	2*17	34	18.7	90/10	585	4No. x 6m	90/10	134	4
																75/10	140	
																63/10	254	
2.5	Bugere	LC	Masaka	Small Stream	5	20	75	7.5	11	2*17	34	18.7	75/10	330	4No. x 6m	90/10	372	5
																75/10	100	
																63/10	330	
2.6	Kawomya	LC	Mpigi	Muyanja Swamp	1	20	55	7.5	11	2*17	34	18.7	75/10	442	4No. x 6m	75/10	320	5
																63/10	389	
2.7	Nalyamagonja	LC	Kalangala	L. Victoria	1	20	75	7.5	11	2*17	34	18.7	90/10	750	4No. x 4.5m	90/10	35	5
																75/10	410	
																63/10	148	
2.8	Gayaza	LC	Bukomansimbi	Nabajuzi Swamp.	3	15	100	7.5	11	2*17	34	18.7	75/10	720	4No. x 9m	75/10	1,200	16
																63/10	680	
2.9	Kyawamala	LC	Bukomansimbi	Nabajuzi Swamp.	1	15	55	4	5.5	1*17	17	9.35	90/10	480	4No. x 9m	90/10	285	12
																75/10	132	
																63/10	212	
3.1	Kukutsi	W	Isingiro	L. Nakivale Swamp	1	15	140	9.2	11	2*17	34	18.7	90/16	1,150	4No. x Ground	75/10	943	6
																63/10	983	
3.2	Kikatsi	W	Kiruhura	Kizaramire V. Dam	1	20	100	11	15	2*17	34	18.7	90/10	868	4No. x 9m	75/10	1,170	8
																63/10	648	
3.3	Rwentamu	W	Lyantonde	Bazana V. Dam	4	20	100	11	15	2*17	34	18.7	75/10	830	4No. x 9m	75/10	360	10
																63/10	163	
3.4	Mirama	W	Ntungamo		3	15	75	5.5	7.5	1*17	17	9.35	75/10	595		75/10	498	12

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		No. of $10m^3$ Elevated Plastic Tank x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
WESTERN AND LOWER CENTRAL REGIONS																		
				R. Muvumba/ Kakitumba/ Enchambu											4No. x 9m	63/10	460	
3.5	Kanyogoga	W	Sembabule	Kyoga Stream Swamp	1	15	75	5.5	7.5	1*17	17	9.35	75/10	370	4No. x 9m	75/10	398	10
																63/10	495	
3.6	Rurama/ Karera	W	Sheema	Karera V. Tank	4	15	75	5.5	7.5	1*17	17	9.35	75/10	430	4No. x 9m	75/10	642	9
																63/10	446	
4.1	Kabumba/ Kitumba	W	Kabale	L. Bunyonyi (Crater Lake)	3	20	140	15	18	3*17	51	28.05	75/10	555	4No. x Ground	75/16	415	6
																63/10	220	
4.2	Nyaruhungye	W	Kanungu	R. Ntungu Swamp	3	20	55	7.5	11	2*17	34	18.7	90/16	500	4No. x Ground	75/10	298	2
																63/10	187	
4.3	Bugara	W	Kisoro	Protected Spring & Runoff	5	15	55	4	5.5	1*17	17	9.35	75/10	250	4No. x Ground	75/10	339	12
																63/10	359	
4.4	Kyondo	W	Rukiga	R. Niehonda/ Nkurwakyondo Stream	5	22	75	11	15	2*17	34	18.7	90/10	350	4No. x Ground	75/10	282	6
																63/10	176	
4.5	Runkonkoma	W	Rukungiri	R. Kisizi/ Stream	2a	25	100	11	15	2*17	34	18.7	90/10	380	6m	75/10	721	10
																63/10	90	
4.6	Nyamasizi	W	Rubanda	Ishasha Stream	5	15	140	9.2	11	2*17	34	18.7	75/16	480	4No. x Ground	75/6	150	6
																63/6	60	
5.1	Kyakuhanda	W	Buhweju	Kabingo Stream	5	15	100	7.5	11	2*17	34	18.7	75/10	165	4No. x Ground	63/10	196	8
5.2	Kanyamukale	W	Bunyangabu	Ntambi Crater Lake	3	20	55	7.5	11	2*17	34	18.7	75/10	361	4No. x 9m	75/10	620	9
																63/10	457	
5.3	Kashozi	W	Bushenyi	Stream	2a	20	75	7.5	11	2*17	34	18.7	75/10	560	4No. x 9m	75/10	420	6
																63/10	364	
5.4	Rwanshetsya	W	Bushenyi	R. Rwanshetya (Stream)	2a	20	75	7.5	11	2*17	34	18.7	75/10	540	4No. x 6m	75/10	240	4
																63/10	196	

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		No. of $10m^3$ Elevated Plastic Tank x Tower Height (m)	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)								
No.	Name	Region				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
WESTERN AND LOWER CENTRAL REGIONS																		
5.5	Karuhusi	W	Ibanda	R.Buhindigya	2a	15	85	7.5	11	1*17	34	18.7	75/10	600	4No. x 3.5m	75/10	1000	10
5.6	Nyacwamba	W	Kamwenge	Small Stream (existing ponds)	4	22	55	7.5	11	2*17	34	18.7	90/10	248	4No. x 9m	75/10	100	4
																63/10	318	
5.7	Rwenkujiro	W	Mitooma	R. Katetera (Stream)	2a	20	55	7.5	11	2*17	34	18.7	90/10	380	4No. x 6m	75/10	264	10
																63/10	392	
5.8	Katonya	W	Rubirizi	L. Kamwiga	1	20	100	11	15	2*17	34	18.7	90/10	450	4No. x Ground	90/10	120	12
																75/10	660	

In addition to the above works, the following are inclusive of scheme works as maybe stated in the Bills of Quantities

- Excavation and Earth works within each scheme.
- Provision of Pump house for all pumped systems
- Provision of chain link fence around the abstraction site and pump house.

2.3 Lot 3 - Eastern Province Area

The summary of scope of works for the Twenty-Four (24No.) Off-Farm Irrigation Infrastructure and Facilities. (Full details are in Bills of Quantities.)

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		4No. x 10m³ Elevated Plastic Tank	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)					Tower Height (m)			
No.	Name	Type				Q (m³/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
EASTERN																		
1.1	Kapsarur	GFS	Bukwo	R. Kiretei	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	140/16	2,640	N/A	90/16	530	26
																75/16	480	
																63/16	505	
1.2	Kululu	GFS	Bukwo	R. Amanang	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	160/10	1,840	N/A	110/10	375	22
																75/10	660	
1.3	Lwongon	GFS	Bukwo	R. Siit	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	160/10	3,640	N/A	63/6	20	3
1.4	Kongta-Tulwo	GFS	Bukwo	R. Kubau		N/A	N/A	N/A	N/A	N/A	N/A	N/A	160/10	5,000	N/A	75/10	374	9
																63/10	120	
1.5	Weere	GFS	Kapchorwa	R.Seremityo	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	140/10	2,540	N/A	63/6	80	5
1.6	Tuikat	GFS	Kween	R. Kiretei	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	110/10	1,540	N/A	90/10	70	2
1.7	Mutufu	GFS	Sironko	R. Sironko	1	20	85	11	15	2*17	34	18.7	75/6	740	9	90/6	740	30
																63/10	240	
2.1	Luwambi	GFS	Bududa	R. Tsutsu	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	160/10	1,200	N/A	90/6	270	13
																75/6	300	
2.2	Nalwanza	GFS	Bududa	R. Maaba	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	160/10	1,490	N/A	110/10	115	8
																90/10	210	
																63/10	270	
2.3	Iyolwa	SPIS	Tororo	R. Malaba Swamp	1	20	55	7.5	11	2*17	34	18.7	90/10	1,240	9	90/6	40	1
2.4	Mukuju	SPIS	Tororo	Apuwai Dam	4	20	75	7.5	11	2*17	34	18.7	90/10	880	6	110/6	840	14
																90/6	460	
																75/6	1,030	
																63/6	300	

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		4No. x 10m³ Elevated Plastic Tank	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)					Tower Height (m)			
No.	Name	Type				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
2.5	Nankusi	GFS	Mbale	R. Namatala	2b	N/A	N/A	N/A	N/A	N/A	N/A	N/A	140/10	2,840	N/A	110/6	65	13
																90/6	420	
																75/6	110	
																63/6	220	
2.6	Buwebere	GFS	Manafwa	R. Nagilima	3	20	75	7.5	11	2*17	34	18.7	75/10	70	9	110/6	270	13
																90/6	235	
																75/6	190	
																63/6	125	
3.1	Obajai	SPIS	Kaberamaido	L. Kyoga	1	20	55	7.5	11	2*17	34	18.7	90/10	660	9	90/10	380	7
																63/10	1,310	
3.2	Ajulon	SPIS	Kaberamaido	L. Kyoga Swamp	1	22	75	11	15	2*17	34	18.7	90/10	1,240	9	90/10	780	5
																63/10	360	
3.3	Totolim	SPIS	Kumi	Matata Swamp	1	20	75	7.5	11	2*17	34	18.7	90/10	630	9	90/6	180	3
3.4	Kagologolo	SPIS	Serere	L. Kyoga Swamp	1	20	55	7.5	11	2*17	34	18.7	75/10	240	6	110/6	1,560	9
																90/6	610	
																63/6	920	
3.5	Kitukilo	SPIS	Bugweri	R. Naigombwa Swamp	1	15	85	5.5	7.5	1*17	17	9.35	160/10	1,200	9	90/6	1,070	12
																75/6	405	
																63/6	390	
3.6	Luwanula	SPIS	Mayuge	Swamp	5	15	150	11	15	2*17	34	18.7	90/10	962	3	90/6	1000	2
																63/10	82	
4.1	Namunkanaga	SPIS	Iganga	Swamp	1	20	55	7.5	11	2*17	34	18.7	90/10	506	9	110/6	728	8
																90/6	110	
																63/10	400	
4.2	Namaboni	SPIS	Namayingo	L. Victoria swamp	1	20	55	7.5	11	2*17	34	18.7	90/10	1580	9	90/6	1,500	15
																63/10	260	
4.3	Buyemba	SPIS	Tororo	Swamp	1	20	**55**	11	15	2*17	34	18.7	75/10	962	9	90/6	1580	8
																63/10	260	
4.4	Habayaga	SPIS	Namayingo	L. Victoria swamp	1	20	55	7.5	11	2*17	34	18.7	90/10	930	9	110/6	728	12

Scheme			District	Water Source Name	Abstraction Type	M & E Works							Transmission/ Pumping Mains		4No. x 10m³ Elevated Plastic Tank	Distribution Mains		Farm Gate Hydrant
						Submersible Pump Parameters				Solar Array (based on 550Wp Panels, $V_{max.}$ = 40.8V, i_{sc} = 13.9A)					Tower Height (m)			
No.	Name	Type				Q (m^3/hr)	Head (m)	Motor (kW)	Inverter (kW)	Strings (No.)	Qty. (m)	Power (kW)	OD/ PN (mm)	Qty. (m)		OD/ PN (mm)	Qty. (m)	
																90/6	110	
																63/10	350	
4.5	Gweri	SPIS	Soroti	Awoja Swamp	1	22	75	11	15	2*17	34	18.7	90/10	982	9	90/6	1150	12

In addition to the above works, the following are inclusive of scheme works as maybe stated in the Bills of Quantities

- Excavation and Earth works within each scheme.
- Provision of Pump house for all pumped systems
- Provision of chain link fence around the abstraction site and pump house.

2.4 Work to be executed by others

Not Applicable (N/A)

3. PARTICULAR SPECIFICATIONS

This chapter is divided into two parts, each corresponding to a part of the Works as defined in chapter 1. Clauses relating to Part 1, 2, 3 and 4 of the Works are prefixed 3.1, 3.2, 3.3 and 3.4 respectively.

References to clauses are to those of the 4th Edition of the Civil Engineering Specification for the Water Industry (CESWI), unless stated otherwise.

3.1 Traffic Requirements

The Contractor shall comply with the provisions of the highway and road safety codes issued by the Government of the Republic of Uganda.

3.2 Surface Boxes and Guards

All valves, unless otherwise stated, shall be provided with surface boxes. The surface boxes shall be of those type given in the Standard Details Drawings. The cover of the surface box shall be lockable and the cover shall be fixed to the base by a welded bolt.

3.3 Excavation

Trenches for uPVC pipes laid in the road reserves or underneath roads shall have a minimum cover of 1.2 m over the crown of the pipe. Trenches for ductile iron pipes, or steel pipes or uPVC pipes laid in open fields not subject to traffic loading shall have a minimum cover of 0.90 m above the crown of the pipe.

Scrub, hedges, debris and other obstacles such as huts, trees etc. along the routes of the pipelines shall be cleared to the satisfaction of the Project Manager. The Project Manager reserves the right to restrict the width of clearance due to the proximity of roots, houses, public utilities or other such permanent obstructions. All trees within 2 m of the pipeline centre lines shall be felled and the roots grubbed up. Trees with a girth of less than 0.5 m shall be deemed to be included in the clearance of scrub etc. and shall not be paid for separately.

Before excavating across any public road, the Contractor shall give 10 days' notice in writing of his intention to excavate, shall satisfy the Project Manager, the Police and other traffic authorities, as to the precautions he proposes to take and the signs and lights to be provided and operated. The Contractor shall further give the Project Manager 24 hours' notice before excavating across any private road or track. The cost of providing all diversions, signs, signals, operations, flagmen and the like will be at the Contractor's expense and shall be deemed to be included in the Contract, whether these are expressly billed or not.

All surfaces of roads, paths, fields, gardens, verges etc. whether public or private, which are disturbed during the execution of the Contract, shall be initially restored on a temporary basis by the Contractor. Permanent reinstatement shall commence only when the backfilled material has properly consolidated. The cost of restoration shall be deemed to be included in the Contract whether these have been expressibly billed or not.

Permanent restoration shall not commence until the Project Manager has given written

permission to proceed. It shall be carried out with materials similar to those which were used in the original surface and to the satisfaction of the Project Manager and/or the responsible owner or Authority.

Trenches, channels, and kerbs shall be reinstated to the condition in which they were before excavation was commenced. The final surface of the trench shall be flush with surrounding ground. The width of reinstated surfaces, due to be measured for payments, shall correspond to the specified width at that location.

For the purposes of the 4th edition of the Civil Engineering Standard Method of Measurement, hereinafter referred to as CESSM4, the classification of excavation shall be as follows.

- Topsoil shall be regarded as any soil which, on visual examination, can be seen to have been broken down by agricultural cultivation, and/or is capable of supporting plant growth.
- Rock shall include any material which, in the opinion of the Project Manager, requires for its removal the use of explosives, sledgehammers and wedges, breaking tools or which cannot be removed by a 145-kW tractor with rear mounted heavy-duty ripper.

Individual boulders, each greater than 0.2 m^3 in volume shall be included in this class when their nature and size are such that they cannot be removed without recourse to the stated methods. Where their aggregate volume is 50% or more of the total volume of material removed it shall be measured as rock throughout.

3.4 Pipe Bedding

The Contractor shall give notice to the Project Manager after completion of trenching of his intention to lay the pipeline. The Project Manager will jointly with the Contractor inspect the trenches and determine the type of bedding for various sections of the trenches as follows:

- pipes which will be bedded on the original ground.
- pipes which will be bedded on selected excavated material (depth as shown on Standard Drawings)
- pipes which will be bedded on imported material (depth as Standard Drawings)

3.5 Concrete Protection to Pipes

All pipes at public road crossings shall be provided with a class C15 concrete surround (see Standard Drawings). All pipes where the cover stipulated in clause 3.1.6 of the specifications is not achievable shall be provided with a class C15 concrete surround.

3.6 Completion of Pipe Surround

The Contractor shall give notice to the Project Manager after completion of trenching of his intention to lay the Pipe. The Project Manager will jointly with the Contractor inspect the trenches and determine the type of pipe surrounds required for different sections of the trenches. The types of surrounds will be as follows:

- non-selected excavated material other than the topsoil, rock or artificial hard material;
- selected excavated material;
- imported granular material.

Indicative quantities of surrounds in the various categories have been included in the Contract. The final quantities shall be as determined on site.

3.7 Protection of Ferrous Pipes, Joints and Fittings

External painting of pipe fittings is not deemed adequate protection, and therefore shall not be permitted. The Contractor shall present to the Project Manager a sample of the material he intends to use for approval, prior to ordering fittings. Protections shall be provided to all fittings falling in this category, and the cost of so doing shall be deemed to be included in the Contract.

3.8 Marker and Indicator Posts

Marker posts for fittings and pipeline structures shall be of design as shown in the drawings, and shall be located within 3 m of the fittings, and to minimise the possibility of traffic/pedestrian damage, and damage from future pipe laying/fitting repair operations. Marker plaques shall be aluminium plates 150 x 150 x 3 mm. They shall be engraved with the pipeline diameter and offset distance prior to installation.

3.9 Precautions Prior to Testing Pipelines

Pressure testing of pipelines against a closed valve shall be avoided. If the circumstances are such this is not avoidable, the Contractor shall seek the approval of the Project Manager prior to undertaking such a test.

3.10 Testing of Pressure Pipelines

The pipelines shall be subjected to a hydrostatic testing prior to commissioning. The test pressure shall be:

- **Transmission pumping line:** Operation pressure or static pressure plus 5 bar, whichever is greater, but at least nominal pressure plus 5 bar.

- **Distribution network:** nominal pressure plus 5 bar,

- **Thermoplastic pipes:** as per the manufacturer's instructions or DIN.

The operation pressure includes the pressure of surge effects.

For concrete or cement-mortar lined pipelines, the section under test shall be filled with water to the required pressure and allowed to stand for 24 hours before the test procedure commences.

For the initial construction period the lengths of pipelines to be tested shall not exceed 0.5 km. At the discretion of the Project Manager this length may, as the Contract proceeds, be extended to a maximum of 1.5 km.

Before testing commences, all anchorages shall be in position, all concrete thrust blocks shall

have attained their required strength and, where pipe joints are deflected to produce large radius curves, the backfill between the pipe body and the trench side shall be compacted to the final requirements. The Contractor shall provide for transmitting the unsupported end thrusts to solid ground.

The Contractor shall fill the pipe with water and shall steadily increase the pressure to the working pressure of the main. The pressure shall then be increased in increments of 1.0 bar, with a pause of one (1) minute between each increment until the specified test pressure is achieved. After a period of thirty (30) minutes, the quantity of water required to restore the pressure back to the test pressure shall be measured. This process shall continue for a minimum period of three (3) hours.

If the amount of make-up water in the three hours test exceeds the specified quantity, the Contractor shall locate and repair the leaks, then repeat the test all at his own expense. The test on each section shall be repeated until the specified degree of water tightness has been obtained.

3.11 Disinfection of Water Mains

The Contractor shall disinfect all new mains intended for conveyance of potable water before they are put into service.

Pipelines that are to convey potable water and have successfully passed the hydrostatic test, shall be scoured out until the wash water runs clear. They shall then be recharged with potable water containing at least 50 mg/l of free chlorine. The chlorine shall be derived from a 1% solution of calcium hypochlorite in water. The solution shall be added in a manner and rate approved by the Project Manager.

The pipeline shall then be allowed to stand for a period of at least 24 hours during which period all intermediate in-line valves shall be operated at least once. After this period, the residual free chlorine shall be measured at the end of the pipeline furthest from the point of injection of the chlorine solution. If the free residual chlorine is less than 10mg/1, the sterilisation process shall be repeated until this value is achieved.

The Employer will supply sufficient potable water for one sequence only of the scouring, sterilising, re-charging and commissioning procedures as defined. The Contractor shall be deemed to have allowed in his rates the cost for the potable water and shall be also deemed to have allowed in his rates, for any re-sterilisation including the cost of potable water, deemed necessary by the Project Manager.

3.12 Survey of Pipeline Routes

The Project Manager has carried out a preliminary survey of pipeline and fixed the appropriate route as indicated on the Drawings.

The Contractor, in conjunction with the Project Manager, shall set out and agree the final pipeline route and shall undertake a detailed survey of the agreed route prior to the commencement of construction work. The Contractor shall submit the results of the survey to the Project Manager in the form of longitudinal sections and plans drawn to a scale to be decided by the Project Manager. They shall conform to the following.

- The length of the route shall be accurately measured and chainage markers (50 mm x 50 mm timber pegs or similar approved) fixed at 50 m intervals and clearly marked with the chainage at that point.

- Using modern survey equipment approved by the Project Manager, ground levels shall be taken at intervals agreed with the Project Manager. Generally, a 25 m interval will be acceptable though this is to be reduced as necessary to ensure any abrupt changes in level are recorded.

- Levels shall relate to the datum given in Chapter 1 of this Specification, and permanent benchmarks shall be established, clear of the proposed pipeline, at intervals along the pipeline route.

The Project Manager will review the pipeline profile and amend it where necessary including any revisions to the number and position of air valves and washouts.

Route surveying shall be completed, and approved Pipe Laying Drawings issued and approved, before excavation and pipe laying begin.

3.13 Pipe Laying - Controlled and Non-Controlled Sections

The criteria for the level and gradient to which pipe shall be laid are divided into two categories as follows.

"Controlled Sections" comprise those sections of the pipeline where pipe gradients will be subject to the following.

- The cover above the crown of the pipe to ground level shall be a minimum of that stated in Clause 3.1.6.

- The upward gradient shall be steeper than 1 in 500 with flow, or steeper than 1 in 300 against the flow.

- The positions of the high and low points shall be determined from the Contractor's detailed route survey and shall be as far apart as ground levels permit, with the depth of the pipe being increased from the minimum by as much as 1 000 mm to avoid high points at small undulations.

The Contractor shall ensure that the required pipe levels and gradients along "controlled" sections comply with the above criteria.

"Non-Controlled Sections" shall comprise the remaining sections of the pipeline which shall be laid to stipulated cover as specified in Clause 3.1.6.

3.14 Pipeline Materials

All pipelines of size equal to or bigger than DN 100 shall be in uPVC or equivalent quality material in the distribution network. Pipes of smaller size have been specified as HDPE. However, any pipeline of equal or better quality will be acceptable. House connections shall be in HDPE.

The transmission pumping line shall be in uPVC /ductile iron/steel according to the Contract agreement. Material specifications are given below:

3.14.1 Pipes of Ductile Cast

- **Standards and Codes of Practice**

  The latest editions of the following Standards and Codes of Practice shall apply:

  Standards:

  - ISO 2531
  - DIN 28600 pp
  - DIN 30674, Part 1

  Codes of Practice:

  - DVGW GW 5
  - DVGW GW 6
  - DVGW W 342

- **Descriptions for Straight Pipes**

  - Coefficient k=9
  - Centrifugally cast
  - Automatic joints with synthetic ring seals (TYTON or equivalent)
  - Internal coating: Blast furnace cement mortar lining for

    DN 200 3.0 mm

    DN 300 3.0 mm

    DN 400 5.0 mm

  According to DVGW W 342 or equivalent

  - External coating: The pipes and parts shall receive external protective coating as follows:

  Bituminous coating acc. To. DVGW GW 5 pp., class GA 2.2 for tropics and

Polyethylene-coating of extra thickness acc. to DIN 30674, Part I

- Flanges

Dimensions acc. to ISO 2531, Items 25 pp are valid

- Standard Fittings and Specials
  For nomenclature and all other details, ISO 2531, Items 25 pp are valid. External and internal coatings as above

  Coefficients K = 14, 12 as specified

- **Welded Specials**

  - Welded tees shall be used only for blow-offs, air vents, etc. In both cases a short pipe of 4.0 m length shall be fitted out with a welded-on flanged spigot. Welding shall be carried out in the manufacturer's plant with welding method and materials to be approved by the Project Manager.

  - Branches of eccentric tees for blow-offs shall be welded to the through-pipe at an angle of 11¼° to the tangent.

  - Branches for air vents shall be on the crest in symmetrical position.

  - Otherwise, all provisions of ISO 2531 are valid and all foregoing specifications.

  - External and internal protective coatings as above.

3.14.2 Steel Pipes (DIN Specifications for Steel Water Pipes)

- **Standard of Manufacture**

Steel water pipes will be delivered in accordance to the requirements of DIN 2460 (Specification for Steel water pipe). Pipes themselves will be manufactured and tested according to DIN 1626.

- **Selection of Steel Grade, Minimum Thickness and Working Pressure**

The nominal pressure of the pipeline, trench depth, type of pressure loading (static or pulsating) shall be advised to the manufacturer. The wall thickness and steel grades for steel pipes shall be selected from Table 3 of DIN 2460 reproduced below to suit the working requirements of the system if the following conditions apply:

- Trench depth does not exceed 6m for DN 500 and below, and 4m for above DN 500

- Vehicle loading imposed by SLW 60 load according to DIN 1072

- Internal pressure is predominantly static (not pulsating)

			Pipeline Pressure Rating PN (bars)				
Size DN	**Outside Dia., da**	**Thickness**	**St37.0 Vn=0.9**	**St37.0 Vn=0.9**	**St52.0 Vn=0.9**	**St37.0 Vn=1.0**	**St52.0 Vn=1.0**
mm	**mm**	**mm**	**Test Report 2.2**	**Cert. 3.1B**	**Cert. 3.1B**	**Cert. 3.1B**	**Cert. 3.1B**
80	88.9	3.2	63	80	125	100	125
100	114.3	3.2	50	63	100	63	100
125	139.7	3.6	50	63	80	63	100
150	168.3	3.6	40	50	63	50	80
200	219.1	3.6	32	40	50	40	63
250	273	4	25	32	50	40	50
300	232.9	4.5	25	32	50	32	50
350	355.6	4.5	25	32	40	32	50
400	406.4	5	25	32	40	32	50
500	508	5.6	25	25	40	25	40
600	610	6.3	20	25	32	25	40
700	711	6.3	16	20	32	20	32
800	813	7.1	16	20	32	20	32
900	914	8	16	20	32	20	32
1000	1016	8.8	16	20	32	20	32
1200	1219	11	16	20	32	20	32
1400	1422	12.5	16	20	32	20	32
1600	1626	14.2	16	20	32	20	32
1800	1829	16	16	20	32	20	32
2000	2032	17.5	16	20	32	20	32

Should the trench depth exceed the above values or the internal pressure is fluctuating than wall thickness should be checked according to DIN2413 for suitability and adjusted if necessary.

- **Pipe Ends**

Pipe shall be furnished with either of the following ends:

- Bevelled for joining by butt welding according to Clause 4.2 of DIN2460 and Clause 4.10.5 of DIN 1626, I.E bevel angle 30deg. +5/-0 AND ROOT FACE 1.6MM +/- 0.8 for wall thickness, s >&=3.2mm
- With Spigot and Sockets for welding Clause 4.3 0f DIN 2460
- With Socket and Spigot with Rubber Gasket Push In Joints Clause 4.3 of DIN 2460

- **Lengths, Dimensional Tolerances and Visual Inspection**

Pipes shall be delivered in 12 m specified lengths from 323.9 mm and above, and 6 m specified lengths for below 323.9 mm. **Tolerance on length** will be in accordance with Table 5 of DIN 1626 reproduced as follows:

	da < & = 500	**da > 500**
Up to 6 m length	+10/-0	+25/-0
6 to 12 m length	+15/-25	+50/-0

Tolerance on diameters and ovality shall be in accordance Table 6 of DIN 1626 reproduced as follows:

Outside diameter, da	**Diameter Tolerance at ends and on body**	**Diameter Tolerance over 100 mm from ends by agreement**	**Ovality Tolerance**
< 200	**+/-** 1% da (up to +/- 0.5 mm permitted in all cases)	+/- 0.5**%** da (up to +/- 0.3 mm permitted in all cases)	Within permissible deviations on diameter
200 to 900	+/- (0.5% da + 1) mm	200 < & = da <300; +/- 1.0 mm 325 < & = da <1000; +/- 1.6 mm	2%; not guaranteed if da/s > 100
1000 & >	+/- 6 mm	By agreement	Ditto

Ovality shall be calculated as 200 x (da_{max} - da_{min}), in % where da_{max} and da_{max} is the greatest and smallest measured outside diameter respectively.

Thickness tolerances shall be in accordance to DIN 1626 Clause 4.10.2.2:

Thickness, s	**Tolerance**
Up to 3 mm	+ 0.30/ -0.25 mm
Over 3 mm to and including 10 mm	+ 0.45 mm/ -0.25 mm
Over 10 mm	- 0.5 mm, upper limit by mass deviation

Thickness shall be measured at pipe ends with suitable instruments.

Straightness: straight to the eye as in DIN 1626 Clause 4.10.3.2, but special requirements may be agreed.

Weld reinforcement height tolerances shall be in accordance with Clause 4.10.4 of DIN 1626:

Thickness, s	**Tolerance**
< & = 8 mm	< & = 2.5 mm
Over 8 mm up to and including 14 mm	< & = 3.0 mm
Over 14 mm and including 40 mm	< & = 4.0 mm

Visual Inspection and defect removal (DIN 1626 Clause 5.3.4.2):
Besides the above dimensional checks, all tubes shall be inspected internally and externally visually for surface appearance. Slight manufacturing surface irregularities such as raise or depressed areas or grooves allowed so as the minimum wall thickness tolerance is not exceeded (DIN 1626 Clause 4.7.2). Defects may be removed in a proper manner so long as minus wall thickness tolerance not exceeded (DIN 1626 Clause 4.7.3).

- **Testing**

Hydrostatic Testing (Clause 5.5.6 of DIN 1626)

All pipes shall be hydrostatically tested. Works Test Pressures shall be **50 bars** unless the hoop stress induced exceeds **90% of the minimum yield stress** of the steel calculated in accordance with DIN 2413 in which case the latter resulting test pressure shall be complied with. The results of all hydrostatic tests shall be recorded on a pressure-recording chart. All test pressures must be held for 5 seconds.

Non-Destructive Testing (Clause 5.3.3 of DIN 1626)

All welds shall be subjected to non-destructive testing. The test may be ultrasonic flaw detection or radiographic means.

Destructive Testing (Table 7 of DIN 1626)

- Chemical Composition

The pipe manufacturer shall carry out a chemical analysis of each heat of steel supplied. The test may be done on finished tube or the sheet steel or strip at the manufacturer's discretion.

- **External Coatings of Pipes and Fittings**

Pipes and fittings will be coated externally in fusion bonded epoxy powder (EP Powder) to DIN 30671 (Specification for Thermoset plastic coatings for buried steel pipes) to a minimum thickness of 350 microns. Pipes and fittings will be coated only in factory conditions.

Prior to external and internal lining, all Pipes and Fittings will be blast cleaned to DIN 55928 Part SA 2.5 quality with a surface profile of 38 - 102 microns. All blasting cleaning machines will be fitted with air-wash systems to remove dust and fines from the surfaces during grit blasting. All surfaces will be cleaned of dust by compressed air prior to coating.

The following tests shall be done by the pipe manufacturer or coating applicator during pipe coating operations:

- Standard of cleanliness of blast cleaned surface as per Clause 4.1.1 of DIN 330671
- Surface coating thickness measurement as per Clause 5.3 of DIN 30671
- Freedom from imperfection by spark detection test as per Clause 5.4 of DIN 30671

The following tests shall be done on pipe sections or steel plate specimens coated with epoxy powder by the epoxy manufacturer once every three years:

- Impact Strength
- Indentation resistance
- Flexibility

- Coating resistivity
- Flexibility
- Adhesion
- Heat reversion
- Cathodic disbondment

The epoxy powder used will be Basepox PE50 – 1080 manufactured by BASF AG.

- **Cement Mortar Linings for Pipes and Fittings**

All pipes and fittings will be lined internally in cement mortar to DIN 2614 Type N.

Prior to cement mortar lining, the surfaces of all pipes and fittings surfaces shall be checked to ensure they are free of rust, scale, loose weld beads, grease, oil, and other impurities. Slight rusting from hydrostatic testing is permitted (DIN 2614 Clause 6.2).

Application Procedure: Cement mortar linings shall be applied by centrifugal spraying with stationary pipe and subsequent rotation as in Clause 4.1.2 of DIN 2614 (Procedure II). Where the shape of the fittings are such that application by centrifugal lining is precluded, linings will be manually applied as in Clause 4.1.3. of DIN 2614 (Procedure III).

Cement: Portland cement shall conform to DIN 1164 Part 1.

Sand grading size: A Sieve analysis will be carried out a minimum of twice a year on sand use according to ISO 3310 Part 1. Fines of up to 0.125 mm in size shall not exceed 10 %. Maximum particle size shall not exceed 2 mm and 1.5 mm for sand used in pipefittings linings respectively.

Mixing water used shall be potable and have a conductivity of less than 2000 uS/cm and a $KmnO_4$ consumption of less than 10 mg/l when tested according to DIN 36404 Part 8 and DIN 38409 Part 4 respectively.

The maximum sand to cement ratio for pipes and fittings will be 2:1 by weight and shall be checked once each week of lining application according to Clause 7.4 of DIN 2614. The **water to cement ratio** shall also be checked once each week of lining application Clause 7.4 of DIN 2614.

Lining thickness of pipes shall be in accordance with DIN 2614 Table 4

Pipe DN	Min. Single Value	Max. Single Value
< & = 150	3	6
200 – 300	4	7
350 – 600	5	8
700 - 900	6	9
1000 – 1200	8	11
> 1200	12	15

Lining thickness of fittings shall be in accordance with DIN 2614 Table 5.

Pipe DN	Nominal	Min. Single Value	Max. Single Value
< & = 300	5	3	10
350 - 600	7	5	10
700 - 900	10	8	12
1000 - 1200	12	10	15
> 1200	15	12	19

Lining Thickness shall be measured on **each pipe and fitting** using a hardened graduated steel spear for wet linings or with an electromagnetic or magnetic measuring instrument for dry linings. The average of thickness readings taken from 4 points spaced at 90 degrees along any cross-sectional plane at least 50 mm from the pipe ends shall be calculated and this average shall fall within the tolerances above.

Compression and Flexural Tests on Mortar prisms prepared from mortar. Mortar being used in lining operations shall be tested according to DIN EN 196 Part1 and shall have a minimum compressive and flexural strength of 50 N/mm^2 and 5 N/mm^2 after 28 days. Tests will be carried out twice a year per cement mortar type; each type being identified by a particular mixing ratio and materials.

Curing Period: Pipes and fittings shall be kept damp for a minimum of 7 days at ambient temperatures of greater than 5 degrees C. Pipes shall be dispatched only after the periods stated below are met and only if under the following conditions:

	5 – 15 degrees C ambient	> 15 degrees C ambient
< & = DN 600	14 days	7 days
> DN 600	14 days	Days

Cracks in Linings DIN 1624 Clause 6.5: Single cracks shall not exceed 2.5 mm. Expansion cracks as a result of transport or in service use wider than 1.5 mm shall be repaired unless it can be demonstrated to the satisfaction of the purchaser that cracks will heal autogenously under constant soaking of water.

Condition of Linings (DIN 2614 Clause 6.5): Linings of pipes shall be as smooth as possible without surface irregularities exceeding 1 mm in depth determined by measuring the distance from a 30 mm straight edge placed on the lining in the direction of the pipe axis. Localised irregularities of up to 2.5 mm in depth are allowed on fittings.

Cured linings shall not have loose sand particles. Protruding, firmly embedded sand grains shall be permitted.

Hydraulic roughness, ks, shall not exceed 0.1 mm.

3.14.3 Pipes of UnPlasticized Polyvinyl Chloride for Pressure Systems

- **Standards and Codes of Practice**

  The latest editions of the following Standards and Codes of Practice shall apply:

Standards:

- ISO 161
- ISO 2441
- DIN 8061
- DIN 8062
- DIN 8063
- DIN 16451
- DIN 16929
- DIN 19532

Codes of Practice:

- DVGW W 320
- DVGW W 323/1
- DVGW W 325

- **Descriptions for Straight Pipes**

Geometric properties shall be as follows (for PN 10):

DN (mm)	D external (mm)	Thickness (mm)	Chamfer Length (mm)
50	63	3.0	4.5
80	90	4.3	6.5
100	110	5.3	8.0
150	160	7.7	11.5
200	225	10.8	16.0

Wall thickness of pipes shall not be less than above mentioned figures.

- Pipes shall be manufactured by extrusion method.

- Permissible working pressure at different temperatures shall be acc. To DIN 8062 as follows:

Class No.	PN	Permissible working pressure [bar] at		
		20ºC	40ºC	60ºC
3	6	6	4	-
4	10	10	6	1
5	16	16	10	2.5

- Colour shall be dark-grey

3.14.4 Pipe materials shall conform to the following data:

specific weight 1.40g/cm^3

tensile strength not less than 50 N/mm^2

coefficient for thermal expansion approx.	80 x 10^{-6}/K
modules of elasticity	3000 N/mm^2
thermal conductivity approx.	0.15 W/m.K
chemical resistance acc. to	DIN 16929
impact strength acc. to	DIN 8061

- Pipes shall have automatic socket and spigot joints with synthetic ring seal, spigot ends shall be chamfered as mentioned above.
- The pipes shall be designed so as to withstand the load of a heavy truck (load of axle 140 kN) at 0.80 m soil cover under specified bedding conditions.

- **Flanges**

  Dimensions shall be acc. ISO 2441.

- **Standard Fittings and Specials**

  Specials and fittings shall be of uPVC acc. to DIN 8063 or of PVC-coated cast iron acc. to DIN 16451, and form part of the pipe manufacturer's original program.

3.14.4.1 Pipes of UnPlasticised Polyethylene for Pressure Systems

- **Standards and Codes of Practice**

  The latest editions of the following Standards and Codes of Practice shall be apply:

  Standards:

  - ISO 161
  - ISO 3607
  - DIN 8074
  - DIN 8075
  - DIN 16932
  - DIN 16933
  - DIN 16934
  - DIN 19533

  Codes of Practice:

  - DVGW W 320
  - DVGW W 323/1
  - DVGW W 325

- **Descriptions for Straight Pipes**

Geometric properties shall be as follows (for PN 6)

DN (mm)	**OD external** (mm)	**Thickness** (mm)	
103.6	110	6.4	Straight pipes of standard lengths (To DIN 8074 & UNBS US 482:2002)
117.6	125	16.4	
188.2	200	20.5	
211.8	225	32.3	

- Pipes shall be manufactured by extrusion method.
- Nominal pressure shall be defined at 20^{o}C. Permissible working pressures shall be according to the table listed below.
- Colour shall be black
- Pipe material shall conform to the following data:

  specific weight 0.95 g/cm^3

  coefficient of thermal expansion 2 x 10^{-4}/K

  modulus of elasticity 900 N/mm^2

  thermal conductivity 0.41 W/(m.K)

  chemical resistance acc. to DIN 16934

- Permissible working pressure at different temperatures shall be according to DIN 8074, Part 1 as follows:

Class No.	**PN**	**Permissible working pressure [bar] at temperatures equal or lower than**		
		20^{o}C	**30^{o}C**	**40^{o}C**
3	4	4	2.5	1.6
4	6	6	3.2	2.0
5	10	10	6.0	4.0

- Pipe joints shall be for butt-end-welding for pipes of sizes equal to or greater than DN 80 and either butt-end-welding or screwed quick-release couplings for pipes of sizes equal to or less than DN50.
- The pipes shall be designed to withstand the load of a heavy truck (load of axle 140 KN) at 0.80 m soil cover at specified bedding conditions.

- **Flanges**

Dimensions acc. to ISO 2441, Welding necks shall be of uPE. Counter-flanges shall be of uPE.

- **Standard Fittings and Specials**

Specials and fittings shall be of uPE acc. to DIN 19533 and form part of one supplier's original program

3.15 Consumer Meters

All consumer meters shall be Kent PSM, SOCAM, or similar approved by the Project Manager and suitable for DWD operation & Maintenance needs and to BS5728. They shall be equipped with non-return valves and serviceable screens.

3.16 Installation of Gate Valves

Gate valves shall be installed at locations specified in the drawings or as directed by the Project Manager. The Contractor shall install gate valves, complete with chambers and their associated pipework and fittings, in accordance with Standard Detail drawings.

3.17 Installation of New Hydrants

New hydrants shall be installed at locations as in the drawings complete with chambers and their associated pipework and fittings.

3.18 Installation of New Service Pipe Connections

New service connections shall be installed at locations as directed by the Project Manager. The Contractor shall install a service connection complete with stop tap, gate valve, consumer meter and associated pipework and fittings.

3.19 Quality of Work

All replacements of and repairs to service connections, fire hydrants, gate valves and pipes are to be of a high quality of workmanship. All installations are to be capable of withstanding a constant pressure of 16 bar (160 metres head of water) without leakage.

3.20 Appurtenances and Accessories for Pressure Mains

3.20.1 Standards

The latest edition of the following Standards shall apply:

- DIN 1952
- DIN 3202
- DIN 3230
- DIN 3352
- ISO 2441

3.20.2 Factory-Tests and Markings

All items shall be duly factory-tested prior to delivery according to DIN 3230, Parts 3 and 4.

Test-certificates shall be submitted with each set of delivery.

All items shall be duly marked as follows: -

- Nominal diameter
- Nominal pressure
- Material of body
- Direction of flow
- Manufacturer's trade mark
- Maximum temperature of liquid
- Permissible working pressure
- Quality control mark
- Serial number
- Year of manufacture
- Stamp of acceptance
- Hydraulic coefficients
- Number of standards

3.20.3 Flanges

Flanges acc. to ISO 2441 or equivalent standard

3.20.4 Coating

Protective coatings for appurtenances and accessories shall, if not otherwise mentioned, be as follows:

For buried items:

- **internal:** Approved epoxy-resin coating of minimum thickness 300 micron
- **external:** Same as internal

For items installed in manholes or valve chambers or in plants:

- **internal:** Approved epoxy-resin coating of minimum thickness of 300 micron
- **external:** 1 primer and 2 finish coats of approved epoxy-resin

Pigments shall be to the approval of the Project Manager. Colours acc. to the Project Manager's instruction.

3.20.5 Manufacturer

All valves and accessories except for fire hydrants shall be from the same manufacturer. All valves and accessories shall be used for transmission mains and distribution mains as well as for central works, such as tanks, pumping plant, etc.

3.20.6 Gate Valves

Gate valves shall be of advanced design according to DIN 3202 and DIN 3352, Parts 1 and 4, or equivalent standard for free flow with rubber-coated wedge. Nominal pressure shall be as indicated. Valves shall close clockwise with non-raising spindle and shall be provided with maintenance-free stuffing-box. Design shall be such as to allow buried installation. Drive nut shall be square of size 27 x 27 mm. Body and wedge shall be of nodular cast iron, spindle of stainless steel, rolled thread, roll-polished shaft, spindle nut of brass or nodular cast, stuffing-box seal of approved plastic.

3.20.7 Butterfly Valves

Butterfly valves shall be such that the basic body (a) can be equipped with different elements as follows: -

- Standard spindle gear
- Standard spindle extension
- Standard hand wheel
- Standard electric servo-motor
- Standard gravity drive with standard hydraulic lift cylinder and attenuation (incl. Oil tank)
- Flow interceptor with mercury balance and trigger mechanism.

Hence, the family of butterfly valves shall be worked out such as to minimize variety of types and spares to be held.

The elements are specified as follows: -

- **Butterfly valve**

Shall be of advanced design with eccentric shaft and continuous ring seal. Design shall permit adjustment of seal without dismantling the disk. Flanges shall be provided for the drive mechanism. Design must be such as to allow buried installations.

Body and disk shall be of nodular cast iron, seat in body shall be of nickel built-up welding, seal ring of approved synthetic rubber, clamping segments shall be of nodular cast iron and screws of stainless steel, shafts shall be of stainless steel and bushings of nodular cast alloy, ring seals of synthetics and screws of stainless steel.

- **Standard spindle gear**

Spindle thread shall be rolled-on, close clockwise, non-rising. Design shall be such as to allow installation of approved spindle extension of Subsection 10. Drive nut shall be of size 27 x 27 mm for DN up to 400. Gear box shall be watertight with annular gaskets, 0-rings shall tighten

the drive-end bushing. Axial drive-end bearing shall be self-lubricating ball-bearing. Gear-box shall be of cast iron, spindle of stainless steel with rolled-on thread, spindle-nut of nodular alloy cast.

- **Standard spindle extension**

Refer to Sub-section 9.

- **Standard hand wheel**

Refer to Sub-section 9.

- **Standard electric servo-motor**

Refer to Sub-section 19.

3.20.8 Spindle Extensions and Surface Boxes for Gate Valves

Spindle extension for buried valves shall be made up of the following parts:

- 1 drive nut 27 x 27 mm of nodular cast or steel,
- 1 shaft extension, of carbon steel,
- 1 coupling, of nodular cast,
- 1 protective pipe, of PVC or equivalent,
- 1 surface box with lockable cover, and the cover shall be fixed to the base by a bolt,
- All parts to receive one primer bituminous coat,
- One key shall be supplied for every 50 units, but 5 keys at least per contract.

3.20.9 Spindle Extension and Surface Boxes for Butterfly Valves

Same as Sub-section 9, but including:

- 1 indicator, of nodular cast or brass or stainless steel or approved synthetics
- 1 protective pipe, of ductile cast
- One key shall be supplied for every 25 units, but 5 keys at least per contract.

3.20.10 Hand Wheels

Hand wheel shall have dimensions as follows:

For Gate Vlves

of DN	Diameter (mm)	Square Nut (mm)
50	165	14
80	200	17
100	220	19
150	285	19

200	340	24
300	445	27

Hand wheel of nodular cast with approved plastic coating.

For Butterfly Valve drive

of DN	**Diameter (mm)**
150	150
200	250
300	250
400	250
500	400
600	500

Hand wheel of nodular cast with approved plastic coating.

3.20.11 Void

3.20.12 Check Valve of Butterfly Type

Basic design criteria of this valve shall be same as of Sub-section 8 above, but eccentric position of shafts relative to pipe centreline and metallic sealing surfaces. This check valve shall only be for installation in manholes and shall be equipped with a drive weight fixed to a lever, adjustable position.

Materials as per Sub-section 8 above, except metallic seal surfaces, all nickel-plated, lever of welded carbon steel, drive weight of nodular cast.

3.20.13 Air Vents

Air vents shall have 2 chambers, the bigger one shall act when the pipeline is filled or blown off, the smaller one during normal operation. A stop valve incorporated in the body shall permit easy maintenance.

Body shall be of nodular cast, gaskets, of approved synthetics, bolts and nuts of cadmium-plated steel.

3.20.14 Venturi Meters

Venturi meters shall comprise the following elements:

- Venturi pipe to the pressure rating of the pipe
- Connecting pipes with globe valves
- Mechanical flow indicator

The particular elements are specified as follows:

- Venturi pipe to the applicable pressure rating shall be designed conforming to DIN 1952, short length. Body of grey cast, ring-chamber of brass or of grey cast. Maximum differential pressure 0.25 bar.

- Connecting pipes to the applicable pressure rating including drain valves and ventilation valves of globe valve type. Pipes and fitting of copper 12 mm x 1.0 mm. Globe valves of brass, joints for soldering or with thread.

- Mechanical flow indicator, scale: indicating 1 l/s max. 500 l/s, linear, at rated differential pressure of 0.25 bar. Mercury gauge for differential pressure, linearization of p/Q by specially shaped mercury containment. Indicator suitable for incorporation of an integrating meter for 6 digits to be powered by a synchronous motor. Materials: Approved synthetics and stainless steel.

3.20.15 Inlet Strainers

Strainers shall have flanges and a net inlet area of at least 3 x area of DN. The strainer shall be fixed to the flange by bolts.

Body of nodular cast iron strainer of stained copper plate, bolts of stainless steel.

3.20.16 Pressure Reducing Valves / Safety Valves

A pressure-reducing valve shall consist of the main valve and a control valve, including pressure gauge. Valve shall be designed to work at pressures less than 16 bar. Control valve shall be installed in by-pass.

Valve body and bonnet shall be of grey cast iron, with chromium-plated sliding planes, stem of gun metal, spring of special steel, packing of approved synthetics; Spindle shall be of carbon steel. The same material shall be applied for the control valve. Pipes and fittings, including strainers shall be of copper and brass, respectively.

3.20.17 Pressure Gauges

Pressure gauges shall be of minimum Diameter 100mm and all be designed for PN 16 and have metric scale for not less than 15 bar, subdivided into intervals of 0.2 bar, have 3/8” male thread with hexagonal nut. It shall be accompanied by a globe valve with 2 female threads.

Body of gauge shall be of brass or stainless steel, scale of white enamelled plate with black figures and graduation. Membrane shall be of stainless steel, all other parts of stainless steel and/or brass, bronze, and approved synthetics.
Acceptance test for pressure gauges shall be a calibration in the presence of the Project Manager.

3.20.18 Electric Servo-Motors

A complete set shall include:

- 1 Electric motor, IP 44, 127/220 V, Hz

- 1 Worm gear

- 1 Drive wheel for manual operation, self-declutching
- 2 Limit switches for monitoring
- 1 Set of control switches as follows:
    - for gate valve: path-length control for opening (counter-clockwise) and torque moment control for closing (clockwise)
    - for butterfly valves: path-length control for opening (counter-clockwise) as well as for closing (clockwise)

Electric motor shall be of squirrel-cage type, completely enclosed, suitable for installation in moist places. Ball bearings shall be maintenance-free and self-lubricating.

Gearbox shall be of injected cast iron or welded steel. Worm gear shall be of steel / bronze.

3.20.19 Flap Valves

Flap valves for outlets shall be with flange PN 10 or socket as required. Body, flap of nodular cast, axle of bronze, bolt of steel or bronze; seal of rubber.

3.20.20 Pipe Expansion Joints

Pipe expansion joints shall be used for flexible connections between buried pipe sections and sections suspended underneath bridges; these expansion joints shall allow for axial movement in the pipe system due to differential movements between the bridge abutments and the bridge itself, as well as for lateral movement in the pipe system due to vibrations of the suspended pipe section. Pipe expansion joints shall be of the axial type, allowing for lateral movements by bellows-section.

Joints shall be of the multiple-wall type, of high-grade steel No.1.4541 acc. to DIN 17007. Their physical properties like nominal diameter, nominal pressure, joint length, etc. shall be determined on the basis of an analysis of kinematical and strength conditions and in correspondence with those of the adjacent system parts, such as to achieve a good functioning of the complete system.

Internal protection pipes shall be provided for pipe expansion joints in sanitary sewerage and storm water drainage lines.

Installation shall be in such a way that no undue strain in place on the pipe/joint system.

3.21 Pump Control Houses

3.21.1.1 Borehole Pump Houses

The contractor shall construct new pump houses as detailed in Drawings to house the fittings on the pumping mains from the submersible pumps and the mechanical and electrical switch

gear. The pump house will be constructed at locations indicated on the Drawings or as agreed upon with the Engineer.

The submersible borehole water pumps will be powered with Alternating Current (AC) from solar panels. The pumps will be operational for a maximum of 10 hours a day.

3.21.1.2 Road Works

No access road to the sites. No parking spaces shall be constructed at the pump house.

The road shall be constructed on firm ground base where possible. Where an imported sub-base is required, this shall be compacted as provided for in the general specifications. The works shall be laid out to enable rapid drainage of run-off, and at the appropriate location drainage channels shall be provided. The wearing course shall be gravel.

3.21.1.3 Fencing

The Contractor shall erect chain link perimeter fences around the entire works for both pump houses. The fences shall be erected as detailed in the Drawings. Each site shall be provided with a single leaf gate at the location directed by the Project Manager.

3.21.2 Reservoirs

3.21.2.1 Storage Reservoirs

The details of the reservoirs are given in the series of drawings as indicated in the Book of Drawings.

The storage reservoirs are to be 4No. x $10m^3$ for each scheme, except for the Gravity Flow Scheme in Lot 1. They will be supported on either a 1.0m high plinth of or 3.0, 4.5, 6.0 and 9.0m steel towers:-

The Contractor shall excavate the site to the extent of the formation level of the tank foundations. The ordinary excavated topsoil shall be reserved for filling within the site, landscaping, and the balance disposed of. The Contractor shall identify his own disposal sites. The site shall be dug up, raked level and grassed.

The tank shall be provided with an external access ladder. Pipework to and from the tank shall be in steel in sizes given in the book of drawings.

The Contractor shall submit details of the tank and support tower (with calculations to confirm sizing of structural members) before placing orders.

The outlets from the reservoir in each scheme shall be fitted with a DN40 Woltmann-type bulk meter. The meter shall registrar accurately to within +5% in the flow range of 0.3-50 m3/hr.

All the drains and overflows from the tank shall be directed to existing drainage channels. connected to the existing roadside drains. All above ground pipework shall be in steel.

3.21.3 Water Supply System - Mechanical and Electrical Works

3.21.3.1 Solar Power Supply and Installations

The Contractor shall supply and install PV Solar Panel equipment as detailed herein.

3.21.3.1.1 PV Solar Panels

3.21.3.1.1.1 General Electrical and Mechanical Performance

Only certified Polycrystalline and Mono-crystalline silicon modules are generally acceptable. The modules should be certified for compliance with the following specifications:

- International Electro-technical Commission (IEC) 61215/61646 - 1993, Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval (or most recent edition)
- Uganda standard US-469: Crystalline silicon terrestrial photovoltaic (PV) module – Design qualification and type approval (US-469:2005, 1st edition)
- Uganda standard US-564: Crystalline silicon terrestrial photovoltaic (PV) module – Design qualification and type approval (US-564:2005, 1st edition)

The solar modules to be supplied shall be constructed from high efficiency mono or multi-crystalline silicon cells, with cell efficiency of 14% or higher. Crystalline silicon cells and modules to be supplied shall be approved to IEC 61215 standards with an EN-ISO certificate, JCRC-ISPRA 503, PV-GAP, UL listing 1703, NEC 2008 compliant or similar quality type approval. The pertinent conditions are solar irradiance of 1000W/m^2, Normal Testing Conditions (STC), Normal Operating Cell Temperature (NOCT) of 25^{o}C.

The PV modules shall have a minimum warranty of Twenty (20) years on performance and materials, with 10% degradation after 10-years (90% nameplate rated power capacity available after 10-years) and 20% degradation after 20 years (80% name-plate rated power capacity available after 20-years).

The entire laminate of the module shall be installed in an anodised aluminium frame for structural strength and ease of installation
NOTE:

I) The Engineer reserves the right to insist on submission of modules for standard testing of qualification and performance characteristics with respect to these specifications. Performance characteristics established by the methods set out in the above specifications shall be used to verify the output of the modules to meet the system performance requirements.

II) Each module shall have a unique serial number; inside the module encapsulation (i.e. stickers with serial number are not acceptable). Also to be included within the encapsulation is the name of the project, name of client and date of manufacture of the solar module.

The acceptable tolerance shall be +5%-3% respectively for all modules supplied under this contract. The modules to be supplied shall comply with or even perform better to the following temperature coefficients:

- αP_{mpp} : -0.6%/^{o}C
- αV_{mpp} : -100mV/^{o}C
- αI_{sc} : +2mA/^{o}C
- αV_{oc} : -100mV/^{o}C

3.21.3.1.1.2 Bypass diodes

Bypass diodes shall be installed to prevent hot spots in modules, which occur often as a result of partial shading of modules. Built-in bypass diodes ensure peak system performance
Every module in a series configuration of 24/48V or higher nominal voltage shall include bypass diodes in the module terminal-connection box. The diodes shall be replaceable without replacing the module or module junction box.

3.21.3.1.1.3 Labeling and marking of PV Modules

The SPV Modules shall be clearly labeled and permanently marked with a data plate containing the following information:

- manufacturer's name and physical address;
- type/model number;
- serial number;
- the watt-peak power rating at STC
- Open circuit voltage and short circuit current
- Voltage and current at maximum power point
- Tolerance and temperature coefficient
- the date of manufacture and country of manufacture
- Certification, e.g: JCRC-ISPRA/UL listing/PV-GAP quality certification to IEC 61215, ISO certification

The module terminals shall be clearly marked as positive (+) and negative (-) so as to avoid reverse polarity problems.
For the specifications documents of the solar-PV modules, an I-V graph or characteristic shall be included, to show the performance of the said module type in varying irradiance conditions, as well as varying temperature conditions.

NOTE: For purposes of this contract, solar-PV modules shall be specifically marked in way that, the serial number, model number, the date of manufacture, the name of the project and the name of the employer shall be embedded within the encapsulation of the module.

Each Solar Panels unit shall be protected against lightning and short circuit-voltage by appropriate earthing. The cost of this protection shall be included in each unit.

The PV Solar Panels units shall be having an established local representative with adequate workshops and spares to provide after sales support. Each PV Solar Panel shall be rated at 280pW, 12V DC peak power.

3.21.3.1.2 Cables

The cabling for outdoor use shall be Ultraviolet resistant cable with copper conductor of generous size to minimize voltage drops.

Wiring shall be permanently shaded from UV radiation. Wiring shall be 'Flexible multi-strand copper conductor cables in flexible UV resistant (e.g. Neoprene) sheath compatible with gland seals', with any array junction boxes as may be required.

The arrangement of modules on the structure, and their interconnection is designed to enhance servicing and inspection:

- Modules shall first be connected in series strings of individual modules to achieve the desired nominal voltage, and these strings shall be paralleled to develop the required peak current. For modules connected in series, connections from each module shall be looped from one module terminal-connection box of one module to the next
- No more than one cable per gland shall be allowed unless conduit is used, and the cable/conduit entries shall be watertight.
- When modules or strings of modules are thereafter connected in parallel, practical wiring constraints require that at least one array junction box is used, and modules/strings at the correct voltage are connected to the array junction box.

3.21.3.1.3 Support Structures

The Contractor shall supply and install Steel Frames for burglary protection and support to the PV Solar Panels supplied to the Engineer's approval. The Contractor shall be responsible for taking all measurements on site that are necessary for the manufacture of and installing of the Steel Frames. Each Solar Panel unit shall have adjustable steel Burglar-proof rack mounted on an independent steel structure.

All supports and brackets shall be wire brushed and painted one coat of red oxide paint and two coats of high gloss paint prior to and after erection. All nuts and bolts shall be sherardized.

The array support structure shall be fixed (non-tracking), after installation. The tilt angle to the horizontal must be in the range between 10^{o} to 15^{o} after installation on the relevant location.

The structures shall withstand wind speeds of 120km/hr. The structure shall be ground mount and all materials used with the associated standard of works, shall comply with the specifications for rust-free/corrosion resistant metal works.

The structure shall be mild steel and painted with epoxy paint applied in accordance with the paint manufacturer's instructions.

The structure shall accommodate such conduit or trunking and any array junction boxes as may be required to meet the specification requirements for module interconnection.

The structure and mounting arrangements shall be compatible with the earthing/grounding requirements.

Each panel shall be attached to the structure in four places as provided on the panel, and the panel shall not itself form part of the support structure, to prevent torsion forces on the panel.

The contractor shall supply all necessary nuts, bolts, washers etc for mounting the array to the super-structure, and for mounting the super-structure to the roof or vertical pole as may be applicable.

- All nuts, bolts and washers shall be stainless or galvanized steel, and any other mounting material shall be of corrosion resistant material.
- The bolts for fixing the modules onto the structure should be stainless tamper-proof bolts.

3.21.3.1.4 Installation of Array Structure

3.21.3.1.4.1 Orientation and tilt of the PV array

The structure shall be orientated to the south, although this might not be critical. The installer shall note the deviation of magnetic north from true north. The array shall tilt at least 10-15 degrees and not more than 15 degrees from horizontal, to allow water and dust to freely wash off the array.

3.21.3.1.4.2 Selection of the PV array site

The structure and location shall allow an unobstructed solar view; there shall be no shading on any part of the array at any time of the day, in any season. Consideration should be given to possible future shading by vegetation growth (e.g. the position of young trees) over the system lifetime.

Wherever modules are mounted, they shall be accessible for cleaning on a regular basis. However, array Junction box to charge controller cable lengths shall be maximum of 5 meters one way.

Array mounting rack: All parts of the mounting structure shall be Engineered for wind resistance, ease of adjustment, safety and must be corrosion resistant. All metal parts shall be made of rust-resistant material or shall be appropriately painted so as to make such metal parts rust-free.

All the metal parts used to make the mounting rack shall be of the appropriate tensile strength and can withstand the load impact from the solar modules and any other environmental hazards like wind and storms.

Concrete base: The concrete base supporting the solar array in ground shall be made from high quality cement, sand and coarse aggregate, water as appropriate and well mixed and brought to the proper consistency, as required by the standards of international practice.

Support Stand The array support stand shall be made from steel material (well painted, rust and corrosion free), from well-constructed brick supports, or equally approved material in accordance with the prevailing mechanical and civil-works standards. Care must be taken such that the array support structure is strong enough to carry the array even in hazard (wind/storm) situations.

NOTE: The spacing in between the solar panels making up the array shall be appropriate, about 1m, so as to prevent shadowing of any kind from the panels themselves. This also allows for good air circulation within the array, hence preventing heat build-up.

Clearance from Ground: An appropriate clearance of array from ground shall be allowed for so as to prevent interference with the solar modules as a result of running water, vegetation and insect habitat build-up. This also allows for good aeration of the array structure.

3.21.3.1.5 Power Control Unit

As far as is practicable, all controls and indicator lamps shall be grouped and mounted together in a floor or wall mounted panel.

No sharp edges or corners will be allowed, and all exposed screws, bolts or other fittings shall have rounded heads with protective and decorative plating. Panels shall be adequately stiffened and reinforced as necessary to ensure rigidity. All surfaces shall be properly prepared before final finishing and the external appearance shall be of a high standard.

All indicating lamps, instruments and controls shall be, as far as is practicable, of the same manufacture and style to provide uniformity of appearance and to facilitate maintenance.

Externally visible equipment shall be flush mounted, with minimum projection and fixed securely to the front panels or other members. Internal equipment shall be secured to purpose made rails or mounting bars. All fixing shall incorporate shake proof washers or other vibration resistant fastenings.

The precise sitting of the control panels shall be agreed with the Engineer and whilst providing good visibility of the plant shall not interfere with the facilities for maintenance and cleaning of equipment.

Internal wiring shall be coded and in general shall be bunched and run-on trays or in purpose-made slotted plastic cable trunking. Positive fixing of cable ends shall be ensured by purpose made clamps, or pinch type terminals, or by the use of crimped cable tags or other approved termination devices. All cable ends shall be permanently identified.

Grouped terminal blocks of adequate capacity with permanent labels shall be provided for all wires leading to equipment outside the cubicle or panel. Removable covers or other facilities shall be provided for the entry of incoming cables, conduits, trunking, etc., with means of effective earthing to the panel chassis.

If main power terminals are incorporated within the control panel, soldered socket type terminals shall be provided.

Fuses shall be grouped and mounted so as to be readily accessible without danger. Fuses, terminal blocks and all items of equipment shall be readily identified by means of clearly visible labels secured to them by screws or by other approved methods.

All items on the outside face of the panel shall be identified by means of attached white laminated plastic labels engraved with black ciphers.

The layout of the control panel shall be agreed with the Engineer before manufacture. A neat and orderly arrangement is required.

The control cubicle panel, as far as is practicable, shall be manufactured, equipped, wired and tested before delivery to site.

3.21.3.1.5.1 The Inverter unit

The inverter to be used for DC-AC conversion shall meet all applicable IEC, UL, IEEE and NEC standards. It is referred to as a variable speed DC-AC inverter, with pure sine wave output power. Its automatic operation shall include but not limited to start-up, shutdown, self-diagnosis and fault detection. It shall have a Maximum Power Point Tracking (MPPT) technology algorithm so as to maximize PV-array output.

Specific Parameters for the power inverter for solar water pumping applications

No.	Parameter	Requirements
1	Input type	DC power from solar panels
2	Input DC Voltage (maximum power-point –MPP values)	500-650VDC for single phase or 300-430Vdc for single phase
3	Output type	3-phase or 1-phase
4	Output voltage	220-240Vac/380-400-415VAC Pure sinewave
5	Frequency	50Hz (+5Hz selectable speed increase) variable speed
6	System Control	Digital signal Processor, with unity power factor control
7	Power control	Maximum Power Point Tracking at near Unity Power Factor
8	Motor control	Variable speed/frequency control
9	Auxiliary controls	Full-tank shutoff and pump dry-run protection
10	Warranty	5-years

A stand-alone inverter unit for this purpose shall have in-built inverter, isolator transformer, AC disconnect switch, DC disconnect switch, Combiner box and DC 600V fuses. IGBT switching capability should allow for the inverter to supply variable frequency power for the variable speed operation of the water pump.

The inverter unit shall have 95% peak efficiency and total efficiency including transformer losses, in excess of 93% at "near unity" power factor and full-load conditions.

Additional feature required include, surge protection, over voltage and overload configurable run parameters, with digital signal processor control; suitable for solar-PV water pumping applications.

3.21.3.2 Office and Store

Not Applicable (N/A).

3.21.3.2.1 General Building Furnishings - N/A

The following general furnishings shall apply in addition to those contained in the drawings:

- Toilets and washroom shall have the walls and floors tiled with ceramic tiles of approved colour.
- The ceiling shall be in expanded metal lathe and painted with approved colour.
- All the external windows and doors shall be burglar proofed to the Project Managers satisfaction.
- Hard wood skirting, architraves and cornices shall be provided.
- All the whole building shall be painted and decorated.

3.21.3.2.2 Plumbing and Drainage – N/A

Appropriate plumbing for the washrooms shall be provided. Cold water supply shall be installed from the site cold water supply system.

3.21.3.3 Site Works

The site layouts are shown in the Drawings.

Included in the general site works are the following:

- the earthworks necessary for the works
- the inter-connecting pipework and channels
- fencing
- other site structures

These are described below:

3.21.3.3.1 Earthworks

The Contractor shall strip the topsoil from areas where structures, roads, and other works are to be located. The Contractor shall excavate for the structures to the extent of the formation levels

given in the drawings. All excavation works to the formation levels are included in the cost of the structures. The areas within the fencing shall be landscaped as directed. This shall include digging up the area, removal of weeds, raking it level and grassing the area. The grass shall be of type that will grow in the climatic conditions in the project area.

3.21.3.3.2 Drainage

Drainage pipework shall be provided to take all the overflows and drainage of the structures. The drains shall be laid to evenfall, and shall ensure a velocity of at least 0.8m/s. The manholes shall be finished at least 0.3m above the general ground. Pre-cast manholes have been called in the Bills of Quantities. The Contractor may use in-situ concrete if he so desires, as long as this is at no additional cost to the Employer.

Surface water drainage channels have been included in the Bills of Quantities. These shall be concrete or stone lined and constructed to a grade of at least 1%. The Engineer shall decide their final locations on site.

3.21.3.3.3 Other Site Structures – N/A

The Contractor shall provide a pre-cast concrete paved walkway 0.7 - 1 m, walkways within the water treatment works site as directed by the Engineer. The paving shall be of quality and bedded as provided for in the General Specifications.

3.21.3.3.4 Road Works – N/A

The Contractor shall construct an access road to the major delivery areas and provide and parking areas as shown on the drawings. The roads shall be constructed on firm ground base where possible. Where an imported sub-base is required, this shall be compacted as provided for in the general specifications. The works shall be laid out to enable rapid drainage of run-off, and at the appropriate location drainage channels and culverts shall be provided. The culverts shall be at least DN 500 and shall be in concrete or galvanised steel. The wearing course shall be bituminous surfacing.

- **Bituminous Surfacing - General**

The grades and spraying temperatures for approved bitumen used for surfacing shall be:

Prime coat: Cutback M.C.30 - 20 to 60 C

Seal costs: Straight run - 120 to 150 C - 80 - 100 penetration

Heaters used for bitumen shall conform to BS1676 and the heated bitumen shall be applied by self-propelled pressure distributors with spray bars complying with BS1707 or BS3136. Where different grades of bitumen are used, heaters and distributors shall be thoroughly cleaned before the grade of bitumen is changed. Flushings from heaters and distributors shall be drained to disposal pits and not discharged into drains, ditches or watercourses. Any bitumen heated above the maximum specified temperate shall be removed from the Site and replaced at the Contractor's expense. Hand spraying shall only be used if approved by the Engineer.

Where spraying is commenced or stopped, metal sheets or building paper shall be spread across

the width of area to be sprayed to produce a clean sharp edge to the area. The sheets shall be cleaned daily and the building paper destroyed after use.
During spraying, all kerbs, headwalls and other road furniture shall be protected from bitumen splashing. Any such features accidentally marred shall be cleaned immediately.

During the course of the work only essential construction equipment shall be allowed into the area and not allowed to stand on completed work. The road shall not be opened to general traffic until directed by the Engineer.

- **Bituminous Prime Coat**

Immediately before applying the bituminous material, the surfaces to be treated shall have all loose dirt and other objectionable material removed by power brooms. If so ordered by the Engineer, a light application of water shall be made just before the bitumen is sprayed.

MC-30 grade cutback bitumen shall then be applied to the surface at the rate of 1.0l/m^2 or as otherwise directed by the Engineer.

- **Bituminous Surface Dressings**

Binder for surface dressing shall only be applied upon completion of the priming and when any defect to the primed surfaces have been repaired. No binder shall be applied until primed surfaces have been approved by the Engineer.

Aggregate shall be spread, by mechanical chip spreaders, immediately following the spraying of the binder and no work is to commence until sufficient supplies of aggregate are at hand. Manual spreading of aggregate shall only be permitted when approved by the Engineer. After applications of aggregate, the surface shall be lightly broomed to give a uniform coverage with no areas having an excess or deficiency of aggregate. Within twenty minutes of application and brooming of the aggregate, the surface shall be rolled with a self-propelled pneumatic-tyred roller, weighing not less than five tons, until a smooth, well-compacted surface is obtained.

Upon completion, all loose aggregates shall be removed from the surface to disposal off the site.

Bitumen binder shall be straight run 80/100 penetration grade bitumen and the first seal coat shall consist of bitumen sprayed at the rate of 1.2 l/m^2 of surface area and 19mm aggregate spread at the rate of 70m^2/m^3 of aggregate. The second seal coat shall consist of bitumen sprayed at the rate of 1.2 l/m^2 of surface area and 12mm aggregate spread at the rate of 100m^2/m^3 of aggregate.

The aggregate grading should as follow:

SIEVE (mm)								
	20	**14**	**10**	**6.3**	**5**	**3**	**2**	**0.5**
First seal	100	85-100	0-30	0-7	-	-	0-2	-
Second seal	-	100	85-100	0.30	0-10	-	0-2	

And should have the following aggregate requirements:

LAA max. 35
ACV max. 26
SSS max. 12
Fl max. 25

Kerb stone shall be constructed as provided for in the General Specifications.

3.21.3.4 Drawings, Documents and Maintenance Scheme

3.21.3.4.1 Contract Drawings

- The Contractor shall submit to the Engineer in triplicate the following drawings for approval:

  - Electrical Drawings: On the basis of the simplified documents, the Contractor shall prepare the following planning records as supplements to the VOB DIN 18382 Standards:

    Wiring diagram and construction plans and drawings, installation plans; complete cable lists, clamping plans, etc. as well as lists of parts, clearly indicating material and type of proposed equipment.

    This also applies to the control and signal circuits are well as interlocking and interrelated control of other technical sectors. A clear illustration according to pertinent standards is imperative.

    A complete documentation (lists of parts, descriptions, maintenance and operating instructions, test reports and certificates, etc.) shall be submitted, in five copies each, prior to the commencement of installation.

  - Copies of proposed panel layouts.

- Two copies will be retained for record purposes whilst one copy will be returned to the Contractor stamped "APPROVED" and/or supplement with any necessary modifications or revisions. The Contractor shall provide four further copies of finally approved drawings.

3.21.3.4.2 Record Drawings

- Within a period of three weeks following the issue of the "Take-over" Certificate the as-built drawings shall be provided. One set shall be reproducible on plastic (or equivalent) and three sets shall be prints of:

  - Works and general plant layout,

  - As-constructed drawings,

  - Comprehensive diagrams for the control panel showing scheduled functions and

diagram of connection,

- Overall mechanical/electrical and control schedules for the Works with details of interconnections between the various units of the plant,
- Actual (not typical) section drawings where applicable,

3.21.3.4.3 Operating and Maintenance Manuals

- Comprehensive operating and maintenance manuals in English language covering all items of Plant and including all manufacturer's instruction, references, lists, etc. shall be compiled. The manuals have to cover the pumping station and the treatment plant.
- The manuals shall be submitted in five copies and shall cover the testing, operation, control, maintenance, dismantling and repair of all the Plant provided in the Works. All information shall be supported by:
  - Catalogues and brochures,
  - Dimension drawings,
  - Data sheets,
  - Descriptive text,
  - Comprehensive drawings, sketches, plans, sections as required.

The greatest importance shall be drawn to the completeness and clearness of presentation.

- It is emphasized that a collection of standard pamphlets of general nature unaccompanied by drawings and descriptive matter will not be acceptable. In particular, information supplied by Sub-Contractors and manufacturers employed by a Contractor shall be co-ordinated in the comprehensive manual. Cross-references of descriptive texts, drawings and spare part lists must be complete.
- The Contractor shall deliver to the Engineer in duplicate loose-leaf copies of draft operational and maintenance manuals for the Plant two months before start up of the works. The manuals shall be divided into several volumes (e.g. function, operation, maintenance, and overhaul) and shall fully and clearly set out the Contractor's own recommendations and instructions for the satisfactory operation, maintenance and overhaul of the Plant as applicable to each of the installations and devices supplied.
- The text or accompanying diagrams shall in addition show the electrical wiring, handling and erection instructions. Draft manuals shall, during the testing and commissioning of the Works, be carefully checked by the Contractor and updated and modified to ensure that they are fully descriptive and applicable to the final lay-out of plant and process under operational conditions.
- The draft manuals may include manufacturer's standard literature but the Contractor shall

fully supplement the literature by his own descriptive text, drawings, tables, figures, characteristic curves and the like.

- The final approved manuals for the Works shall be submitted prior to the commencement of the Period of Maintenance. They shall be securely bound in A4 sized loose-leaf binders, clearly titled, index linked and cross referenced.

- The final manuals shall incorporate instructions, recommendations and advice for the operation of the entire process covering the full range of flow and raw water conditions and shall include advice on the joint operation and control of all the treatment process units on site. No section of the Works will be certified by the Engineer as completed unless this requirement has been met. The contents of the final manual may be subdivided into the following sections:

  - Basic data of the works,

  - Description of the different units of the Works including supporting sketches,

  - Setting to work procedures,

  - Normal operation,

  - Taking out of service procedures

  - Emergency operation (amount or raw water, temporary deterioration of raw water quality, electricity failure etc.)

  - Water quality monitoring programme including sampling schedule and sampling locations, draft of quality reporting forms according to WDD/NWSC Standard and description of standard methods used for analysis.

- If during the Period of Maintenance, the Contractor or the Engineer has found that the manual should require modification or enlargement as a result of subsequent operational and maintenance experience in the Works, the Contractor shall provide the approved modification for each manual.

- The manuals shall include explanations of the function and purpose of each item supplied and the operational, mechanical and electrical procedures for:

  - Lubrication, checking, calibration (including charts), testing adjustment of each item,

  - Attention at daily, weekly, monthly or other intervals to ensure reliable trouble-free operation,

  - Complete overhaul, dismantling and reassembly, testing and re-commissioning,

  - The identification and selection of suitable lubricants standardized throughout the Works, identifying equivalents of local manufacturer's

  - Defect locating charts to facilitate tracing of the cause of malfunction or breakdown,

- Routine and emergency safety precautions, procedures and recommendations,
- Cleaning of the Plant and its components.
- Guidelines for conservation of equipment in case of taking the equipment out of service,
- Maintenance of protective coating,
- Operational maintenance of the system, performance and treated water quality monitoring and reporting procedures.

- The instruction manuals shall describe the installation as a whole and shall give a step-by-step procedure for any operation likely to be carried out during the whole life of the Plant.
- A separate section of the manual shall be devoted to each size and type of equipment and to each system of Plant. The various sections shall be grouped into separate volumes relating (as appropriate) to functions like operation, maintenance, overhaul etc. The appropriate volume shall contain also a list of spare parts and the required procedure and addresses for ordering them. A list of recommended spare parts to be stored shall be supplemented each item of equipment.

3.21.3.4.4 Maintenance Scheme

- The operation and maintenance instruction manuals shall be supplemented by the supply of a comprehensive yearly maintenance programme for the water works operation and maintenance staff.
- A wall chart or charts shall be provided, covering a period of one year with coloured markers. It shall have vertical divisions in weeks and horizontal divisions for each item of Plant. A fitter's card system shall be provided with at least one card for each item of Plant. The cards shall detail the maintenance required with the relevant spaces for work done, parts required and the like, in order that for each task or day's work, the electrical works and mechanical maintenance staff may be presented with the card for routine work completion and signature.
- The markers shall be arranged with standard colours to indicate work required, parts outstanding, work completed and the like.
- The maintenance scheme shall be provided complete at the time of handing over of the Works. It should have sufficient space for extension to include any further routine work, which may be required.

3.21.3.5 Manual Gantry Crane – N/A

Manual gantry crane above intake, which can move in the vertical and horizontal (one) direction, capable of lifting 500 kg. It shall be complete with support columns, overhead rails, cross beam and crane with horizontal movement.

3.21.3.6 Cabling

Cabling shall be executed according to Clause 4.32. It shall include all cables necessary for proper functioning, such as the following cable connections:

- From metering box to control cubicle 5 x 2.5 mm² Cu
- From control cubicle with 1.5 mm² Cu to the consumers.

3.21.3.7 Lighting

The lighting system shall comply with Clause 4.45 and shall include light fittings with bulbs and tubes, switches, power plugs, cables from control cubicle to the fittings and all fixing material and protection tubing.

The following equipment shall be installed:

- 2 twin-tube fluorescent light fittings with electronic starter with 2 x 40 W tubes for the operator rooms.
- 3 power plugs 240 V and one 3-phase 415 V power plug
- 9 outdoor light fitting according to Clause 4.36 with 250 W High Pressure Sodium discharge lamps including lighting poles controlled by a photocell and contactor in DB.

3.21.3.8 Earthing

The buildings shall be provided with an earthing system as specified Clauses 4.32.3and 4.35.

Instead of rods a loop of copper wire min 95 mm² can be installed below the foundation before concreting with 2 connections to be used later on for the earthing system. For connections of the copper conductors braze pressure clamps shall be used.

3.21.3.9 Lightning Protection

Lightning protection shall be provided for the highest building, consisting of a copper tape with minimum 75mm² cross section installed along the ridge of the roof, with a copper spike peak surpassing the building heights by approx. 50 cm.

The connection to the earthing copper ring shall be executed by using brazed screws and washers avoiding direct contact of galvanized steel with copper.

3.21.4 Specifications of Equipment and Tools

The Contractor shall furnish to each scheme with the equipment and tools listed hereunder.

All tools shall be of high-quality material (chromium-vanadium and high-quality tool steel respectively) and shall be in accordance with the latest standard.

The equipment shall be provided according to the following technical requirements. It shall be of an approved quality and finish.

ITEM NO.	ITEM DESCRIPTION	UNIT	QTY.
	MISCELLANEOUS TOOLS		
1	Square Shovels	No.	1
2	Steel hoe, blade width 200 mm, 1.5 kg complete with good wooden handle	No.	1
3	Heavy duty builder's plastic bucket	No.	2
4.	15mm double braid nylon rope	m	10

4. GENERAL PROVISIONS

4.1 Technical Specifications

The General Specification defines general requirements, materials and workmanship for the execution of civil works. The General Specification also describe the framework under which the contractual works shall be executed and the general activities to be included in the rates for the Permanent Works.

The Particular Specification specifies design requirements and contractual works to be executed under the Contract.

4.2 General Specification

The General Specification is compiled in five Sections:

Section 1:	General Provisions	Section 5:	Electro-mechanical Equipment
Section 2:	Preparatory Works and Site Organisation	Section 6:	Electrical and Protection Equipment
Section 3:	Equipment and Materials	Section 7:	Inspection and Testing
Section 4:	Civil Works		

The Preliminaries comprise mobilisation and general services to be performed under the Contract and shall be quoted separately from the Permanent Works.

The Permanent Works comprise the contractual Civil Works which shall be executed in accordance to the requirements of the General Specification and be quoted for the various sections of works specified in the Particular Specification.

The Testing of materials and equipment (Section 7) shall not be quoted separately and is deemed to be included in the remuneration for the Works.

4.3 Standards

For the description of the quality of materials and work reference has been made, where found necessary, to EN Standards, ISO or DIN. For valves and equipment, reference models were indicated in this General Specification, the Particular Specification or the Bill of Quantities shall serve as benchmarks for design and quality of these particular items that have to be met by the valves and or the equipment to be incorporated into the works.

The Contractor may, however, carry out the Works or provide materials in accordance to other International Standards, provided that the Contractor proofs to the Engineer that their requirements are superior or equivalent to the quality described by the Standards cited in the Specifications.

Should the Contractor desire to carry out works or to substitute goods and materials in accordance to other than EN, ISO or DIN Standards, he shall notify the Engineer thereof, and shall submit with his notice 2 copies in English of the proposed Standard (latest version), and shall not order any material or perform any work unless he has obtained the Engineer's approval of such Standard, together with any other information required by him.

Within 30 days of the signature of the Contract, the Contractor shall provide to the Engineer 2 copies of all Standards (latest editions), which are to apply to materials and workmanship under the Contract, together with an index cross-referencing these Standards with the applicable aspects of the Works.

4.4 Responsibility for Information

The Contractor shall be deemed to have inspected and examined the Site, to have verified the Site conditions and to have satisfied himself, before submitting the Bid and before the Commencement of the Works, as to all matters relative to the nature of the Site within the specified boundaries, details and levels of existing services and connections to be made, the quantity and nature of the work and materials necessary for the completion of the Works, the means of access to the Site and the accommodation he may require, the supply of water and electricity, the climatic, hydrological and geo-hydrological conditions or such contingencies which may influence or affect his Bid.

Any negligence or failure on the part of the Contractor to obtain reliable information on the Site or elsewhere concerning any matter affecting the Contract Agreement shall not relief the selected Contractor from any of his obligations or liability arising from the Contract Agreement.

No claim shall be permitted with regard to the effects of these Site conditions on the execution of the Works.

4.5 Site Meetings

The Contractor shall attend all meetings called for by the Engineer at the Site or in the Engineer's office to discuss the progress of the Works and/or any problems related thereto.

In particular the Contractor shall make arrangements and facilitation for regular monthly site meetings to review the progress of work.

Site meetings shall normally include inspection of the works jointly by the Contractor, the Engineer and the Employer and the Contractor shall make arrangements to facilitate the joint inspection of the works.

The Engineer will prepare Minutes of Meeting (MoM) and submit both the Employer and the Contractor with a copy for comments. Any comments must reach the Engineer within fourteen days after submission day. Beyond this period of time the MoM will be considered as accepted by all parties.

In the event that the Contractor fails to send his representative(s) to any meeting at which his presence has been requested, all decisions shall be taken as if the Contractor had been present and agreed on subsequent actions and orders.

4.6 Progress Reports

The Contractor shall submit to the Engineer on the first day of each week, or such longer period as may be stipulated, a Progress Report showing the progress made in all important sections of the Works since the last report and the overall progress since commencement of the Contract. The progress reports shall be illustrated with significant photos taken during the reporting period.

Report and photos shall be submitted to the Engineer in two copies together with the digital files in pdf-format.

The Progress Report shall be related to the Programme of Works or revisions thereof as are approved from time to time by the Engineer

4.7 Works Included

The remuneration for the various parts of works shall be quoted in the relevant items of the Bills of Quantities, which are deemed to include all works arising from the general requirements specified hereafter, the Bill of Specifications and in the Particular Specification.

The Preliminaries, comprising Contractor's mobilisation, the maintaining of site facilities during the execution of Works, the demobilisation from Site, the structural design, sampling and testing of materials and the topographical survey for setting out the Works, shall be quoted as separate items.

For the Permanent Works to be executed under the Contract, the Contractor shall supply all materials, equipment, temporary works and labour necessary to perform, maintain, test and complete the Works and maintain the completed Works during the Defects Liability Period as required to hand them over to the Employer.

The Contractor shall also furnish all equipment's, materials, specials and labour required to make connections to, to protect, to remove and to rearrange existing services and other structures so that the whole of Works are delivered to the Employer in perfect condition and working order.

Where items are not included in the Bill of Quantities for any such requirements or obligations, the cost of such requirements and obligations shall be deemed to be included pro rata in all other pay items of the Bill of Quantities.

4.8 Measurement of Works

The quantities shown in the Bill of Quantities are estimates only and they may vary during the course of the works. Payment for these items shall be made on actual work done during construction and according to methods of measurement and payment, described in the Preamble to the Bill of Quantities.

Measurement and control of quantities for the elaboration of payment certificates shall be made by the representatives of the Contractor and the Engineer. The Contractor's measurement is always subject to the Engineer's approval.

The Contractor shall provide all assistance, drawings, schemes and all survey instruments and measuring equipment required. The cost for the measurement of works shall be deemed to be included in the respective prices for construction and installation of works.

If the Contractor does not assist or refuses to participate to the measurement of quantities, the quantities measured by the Engineer shall be considered valid.

Wherever levels, measurements, quantities, etc. of any work done cannot be checked at a later stage, the measurements made by the Engineer or approved by him shall be taken to be correct measurements of the work.

Any measurement of quantities taken during the progress of works is provisional and can be declared null and void, if evidence proofs the incorrectness of the measurements. In that case the representatives of the Engineer and the Contractor shall proceed with new measurements.

4.9 Contractor's Staffing and Labour Force

When nominating the representatives and the supervisors to whom the performance of the works on Site will be entrusted, the Contractor shall give full information on their educational and professional background. The replacement of representatives and/or supervisors shall not be allowed without the written approval of the Engineer.

The Contractor shall appoint a safety officer responsible for the implementation of safe working practices throughout the Contract.

Key staff responsible for the correct execution of works (excavation, pipe laying, backfilling, road- and footpath reinstatement, concrete works and framing (shutter works), etc., must be available to the Engineer at any working time.

Foremen responsible for above-mentioned work must have a significant experience in work under the climatic circumstances and must be able to safeguard good workmanship so that the Works are executed according to the Standards.

The Contractor shall also submit details of the Labour Force, which he proposes to employ.

The Contractor shall also submit details of the labour force, which he proposes to employ. Such details shall include Engineers and experts involved; senior staff and specialists, skilled and unskilled labour with indication of the local labour, which the Contractor envisages to employ and the variation in staff and labour levels and their distribution throughout the duration of the Contract.

Child labour shall no be tolerated.

4.10 Contractor's Representative

The Contractor's representative(s)/Project Manager(s) shall have the authority to act on behalf of the Contractor and is/are expected to take part in relevant discussions and decision-making. All decisions given by the Contractor's representative(s)/Project Manager(s) shall be deemed to be given by the Contractor and all subsequent actions shall be based on these decisions.

This representative(s)/Project Manager(s) shall, on request of the Engineer, attend all meetings with the Employer, the Engineer or other parties.

5. SITE INSTALLATION AND PREPARATORY WORKS

5.1 Site Installation

5.1.1 Site Installation and Mobilization

The site installation shall include all site infrastructure, temporary site offices and yards, site laboratory, safety provisions, accommodation and sanitary facilities, provisions for water, energy and access and the installation of signboards in accordance to the requirements of the General and Particular Specification and the Bill of Specifications. The costs of the site facilities described in Chapters 2.1 and 2.2 shall be included in the corresponding unit prices and the unit price of site installation.

The location of all site installations shall be agreed beforehand with the Engineer. The Contractor shall prepare drawings of all sites selected for the site installation showing the location of all buildings, stores, offices, temporary roads, etc. The drawings shall be submitted for approval by the Engineer.

Mobilisation at site(s) shall include all site works, the erection of all site facilities and the mobilisation of all equipment and materials as necessary to carry out the Works under this Contract.

Special attention shall be paid to the safe storage of fuel and lubricants in tanks and safety catchment's basins in order to avoid the contamination of soils, subsoil and groundwater. This applies also for the installation of any workshop or other repair facilities.

The Contractor shall give strict instructions to all persons employed by him to comply with the regulations for groundwater protection. If the Contractor fails to arrange for adequate precautions to avoid any contamination, he shall exchange soils contaminated by him at his own cost and bear full responsibility for any groundwater pollution.

5.1.2 Maintenance of Site Installation

The maintenance of site installation shall comprise the maintaining of all site facilities for the execution of the Works including water and energy supply, the operation and cleaning of site offices, accommodation and sanitary facilities and all temporary works as necessary to ensure access to and proper protection of construction sites including for security, lightening and traffic control during the construction period.

5.1.3 Demobilisation from Site

The demobilisation includes the removal of all site facilities and temporary installations, the demobilisation of all equipment from Site, the removal of all surplus materials, the reinstatement of all damaged or worn access roads and facilities used by the Contractor and the cleaning up of the construction site after completion of the Works.

5.1.4 Costs of Mobilisation, Site installation and Demobilisation

All costs of referred to under this sub-clause 2.1 shall be deemed to be included in the pay item "Site Installation and Preparatory Works" of the Bill of Quantities.

5.2 Site Facilities

5.2.1 Safety and Accommodation

The Contractor shall ensure that all safety and welfare measures strictly comply with the provisions of the regulations in force for health, environment, welfare, safety and groundwater protection.

The Contractor shall provide, at his own expense, for temporary fencing to all parts of the works and sufficient protection of all open excavation to ensure the safety of workmen, for suitable shelters and/or mess rooms for his workmen and supervisory staff and for adequate sanitation facilities.

The Site shall be equipped with sufficient closets, which comply with the regulations for groundwater protection. If the Contractor fails to arrange for adequate precautions and sanitation facilities, the Engineer shall instruct a third party to provide them at the cost of the Contractor.

The Contractor shall have particular regard to the safety of persons and livestock and shall ensure that all-open excavation, access routes and steep or loose slopes arising from Contractor's operation are adequately fenced and protected.

The Contractor shall be held responsible for all necessary safety measures during the duration of the Contract and shall strictly follow the safety regulations in order to prevent accidents.

Proper strutting, sheeting and bracing, protection of slopes, methods of excavation to reduce risks of slides, etc. shall be deemed to be included in the rates and prices entered in the schedule of prices. In the event of soil slides occurring during earthwork, all damage and making good of works shall be at the expense of the Contractor.

If there is an intensive human FS existence around the working area safety barriers and portable bridges (for crossing purposes) shall be located along and over ditches to prevent any accident or injury.

The Contractor shall take all precautions against the contamination of the Works.

5.2.2 Safety of Personal and Visitors

The Contractor shall observe and cause his staff to observe standards commensurate with the nature of the Works. To this end the Contractor shall provide and ensure his employees wear:

- overalls,
- boots or shoes with reinforced toe caps,
- helmets suitable for construction site,
- other protective equipment such as gloves, ear muffs, goggles, etc., as are necessary for particular work.

The Contractor shall further provide helmets and shoes for the Engineer and his staff and for the use of site visitors up to ten in number.

No work shall be permitted to be executed unless the Engineer is satisfied that appropriate safety measures are in place and that the Contractor's employees are wearing suitable safety gear.

5.2.3 First Aid Outfits

The Contractor shall, at his own cost, provide and maintain for the duration of the Contract adequate first aid outfits at all construction sites.

5.2.4 Cleanliness on Site

The Contractor shall make every effort to keep the Site tidy and in orderly manner and to take at any time every possible precaution against the contamination of subsoil and groundwater. The Contractor shall be responsible for making all arrangements for the disposal of solid and liquid wastes from the Site at his own expenses. Furthermore, he shall give strict instructions to all persons employed by him to use the sanitary facilities provided at Site.

If the Contractor fails to keep the site clean, the Engineer shall instruct a third party to carry out the work at the cost of the Contractor.

5.2.5 Water and Energy Supply

The Contractor shall be responsible for and shall make all arrangements for adequate supply of water and energy to the construction Site. He shall also supply safe drinking water for the workmen on Site. The Contractor shall be responsible for the supply of all water required for mixing and curing of concrete and for testing of pipelines and structures.

5.2.6 Maintenance of Traffic

The Contractor shall provide, erect and maintain on the Site and the locations on the access to the Site all traffic signs and traffic control signals, as necessary and/or may be required by the Traffic Police Authority for the safe direction and control of the traffic during execution of the Works.

The location and size of all such signs and the lettering thereon shall be approved by the Engineer before installation.

The Contractor shall relocate, cover or remove signs as required during the progress of the Works.

5.2.7 Use of Public Roads and Temporary Roads

The Contractor shall, at his own expense, carry out all protective works and strengthening of public roads used by him as necessary to avoid damage from heavy loads and plant moved to the Site. The Contractor shall also construct, maintain and remove temporary access roads as he may require for carrying out the works at his own expense.

The Contractor shall observe all restrictions, which apply to public roads, and he shall comply with all reasonable restrictions, which may be imposed by the Engineer, the Employer, the Police or other competent Authorities. This includes save and secure fencing of the respective site, temporary traffic lights and security guards.

The Contractor shall not run tracked vehicles or tracked plant on any public or private road without the written approval of the responsible Authority or Owner and subject to such conditions as those may require.

Public and private roads and other surfaces used by the Contractor shall be kept free from dirt and rubbish and be cleaned with adequate equipment as directed by the Engineer. If the Contractor fails to do so the Engineer can order a third party to do the cleaning on the account of the Contractor.

Immediately after ceasing the use of any temporary road the Contractor shall restore the road to the satisfaction of the Engineer and the responsible Authority or the Owner. These provisions shall apply also to the shoulders, footpaths, drains, etc. of any existing sealed road used by the Contractor or affected by his operations.

5.2.8 Maintaining of other Services / Utilities and Structures

The Contractor shall be responsible for maintaining all water courses, pipes, sewers, drains, electricity and communication cables, other services and structures during the construction of the Works.

The Contractor shall repair to the satisfaction of the Engineer or the concerned authorities, without any delay any damage caused by his operations and maintain existing services during the execution of Works at his own expense.

As soon as an existing service is encountered in the excavation the Contractor shall forthwith call the attention of the Engineer and the appropriate utilities service authority thereto.

Notwithstanding any relevant information furnished by the Employer or the Engineer, the Contractor shall be responsible for ascertaining, from his own inspection of the Site and from the respective utility and other authorities and by excavating and backfilling for trial pits, the position of all mains, pipes and cables whether underground or overhead, within or near the Site.

The Contractor shall, at his own expense, maintain the flow in all sewers, drains, water pipelines and all water courses which may be met during the execution of the Works, allowing none of the waters to flow in the trenches for pipelaying under this Contract.

If an existing utility line is needed to be diverted or demolished, such line shall be diverted or demolished and afterwards relocated and / or repaired as originally found and be approved by the utility / authority.

If any utility intercepts the pipeline route, the Engineer shall have the authority to modify the design and to order deviations from the line and grade. Payments shall be made for the permanent Works only, any other works involved shall be deemed to be included in the rates and prices of the Bill of Quantities.

5.2.9 Temporary Approaches, Bridges, Gangways, etc.

Where any road, path, or right of way is affected by the construction of the Works, and as in the opinion of the Engineer may from time to time be necessary for safe and expeditious access to different parts of the Works, the Contractor shall provide suitable temporary approaches, bridges, gangways, and roads. Particularly, the Contractor shall provide means of access to adjacent occupiers of the land to carry on their normal occupations, and shall indemnify the Employer against any claim for loss of business or amenities.

All such approaches, bridges, gangways and roads shall be maintained in service until all requirements of the Specification have been fully complied with.

All cost of constructing, maintaining and removing all temporary approaches, bridges, gangways, etc. under this sub-clause shall be deemed to be included pro rata in the related pay items of the Bill of Quantities.

5.2.10 Work in Existing Roads and Footpaths

Where existing roads shall be crossed or works are performed in existing roads, the Contractor shall obtain instructions from the Engineer as to the date and hour for the breaking up of the road and the manner in which traffic is to be diverted to other roads. Such deviations shall be provided and maintained by the Contractor at his expense.

All roads used shall be kept free from dust and mud, and unless permission to close certain roads is obtained by the Contractor from the Engineer, at least one half the width of each road (if possible) shall be kept open to traffic.

Men and apparatus shall be provided by the Contractor for pedestrian and for vehicular traffic control when working along or crossing roads. Lamps shall be lighted and warning signboards put up where necessary to ensure, during the progress of work, the safety of traffic using the road, and to prevent unauthorized persons, animals, etc., from straying on to the work.

The Contractor shall be responsible for liaison, co-ordination and arrangements with the relevant authority in the obtaining of consents, payment of fees and all manner of things necessary to comply with the lawful orders of the relevant authorities and the Contractor shall allow for the same in his rates.

All roads, including shoulders and various kind of drains, ditches and footpaths shall be restored to their original condition and carried out to the requirements of the relevant authority as soon as the work along or at the crossing has been completed. All restoration works, such as backfilling and road base course and surfacing, shall be performed to the requirements of the Specification.

5.2.11 Precautions

The Contractor shall take all precautions to avoid damage to any structure owned by third party. If damage occurs, the Contractor and the Engineer shall contact the owner of the damaged structure immediately, jointly, and all necessary repairs shall be made by the Contractor at his own expense, under the direction and to the satisfaction of the Engineer

5.2.12 Signboards

The Contractor shall, at his own expense, provide and install signboards at the site of work and shall remove the same on completion. The signboards shall have a minimum size of 10 m² and generally show the following, in both, Dari and English languages, the names of the Employer, of the Financing Agencies, of the Contractor, of the Engineer, of the Works, the date of commencement and the scheduled date of completion of Works, as directed by the Engineer. The size of the letters shall be not less than 20 cm and clearly legible from the road side.

5.2.13 Cost of Facilities

The costs of all required facilities on Site shall be included in the corresponding items for Permanent works or in the items for Preliminary Works. Where items are not included in the Bill of Quantities for required facilities, the cost of such services, works and facilities shall be deemed to be spread over all items of the Bill of Quantities.

5.3 Preparatory Works

5.3.1 Review of Technical Documents

The Contractor carefully review all technical documents included in the Contract before the start of the Works and the ordering of the required goods. The technical documents are understood to be the following:

Contract drawings (see next paragraph)
Detailed lists of pipes and fittings
Lists of goods and equipment described in the Bill of Specifications
The Bills of Quantities and Specifications
Schedules of nodes for pipe-laying works.

The Contractor shall amend the initial lists, schedules and drawings as may be required and submit three copies to the Engineer.

5.3.2 Contractor's Drawings

The Contractor shall carefully verify dimensions and levels on Site, compare such information with the Contract drawings and bring any errors or omissions discovered therein to the attention of the Engineer, who will give the necessary instructions for update.

Failure to discover and/or to notify the Engineer of any errors or omissions in the drawings shall not relieve the Contractor from being responsible for unsatisfactory or faulty work resulting thereof or from the obligation to rectify and make good such work at his own expense and to the complete satisfaction of the Engineer.

After the Award of the Contract, the Contractor shall prepare all detailed Shop and Working Drawings. The Contractor shall submit for approval to the Engineer one original and two copies of the Drawings.

Additional Drawings, amendments, and/or alterations shall be submitted to the Engineer for approval. Such alterations, which the Engineer may require or which may become necessary during the Works, shall be made by the Contractor without extra charges.

Roads and pavements shall be laid out to plans prepared by the Contractor and approved by the Engineer.

The Engineer will notify the Contractor 14 days after handing over of the soft copies of the Contract Drawings of the format in which all drawings shall be submitted for approval, and which format shall also apply to the As-Built Drawings.

5.3.3 As-Built Drawings

As the work proceeds, the Contractor shall prepare, at his own expense, record drawings based on the Contract Drawings as to portray the Works actually executed. These record drawings shall become As-Built Drawings upon Completion of the Works. These drawings shall clearly show all portions of the Works, in plan, profile and sections and also all deviations from the original drawings.

The complete set of record drawings shall comprise:

- Layouts and profiles of mains
- Node details for all nodes
- Actual drawings of any structures (plan and sections), showing built-in pipes and fittings.

Draft versions of the records drawings shall be submitted to the Engineer for approval and then be completed with any amendments requested by him. On completion of Works the Contractor shall supply to the Engineer the complete set of originals and 3 (three) copies of the As-Built Drawings.

The As-Built drawings shall use the ID-system as set forth in the Particular Specification.

5.3.4 Programme of Supplies and Works

The Contractor shall submit to the Engineer full details of his proposed Supply and Working Programme and its milestones within the execution period as stipulated in the Contract.

The Contractor shall use the CPM for elaboration of the Programme and shall use MS Project as tool.

The Programme shall be deemed to have taken into account the climatic conditions to provide for the supply of the goods and the completion of the Works in the order and within the times specified therein.

The Contractor shall carry out the Contract in accordance with the Programme agreed with the Engineer but he shall in no way be relieved by the Engineer's approval of the Programme of his obligations to complete the Supplies and Works in the prescribed order and by the prescribed Completion Date, and he shall review his progress every month (tracking Gantt chart) and make such amendments to his rate of execution of the Works as may be necessary to fulfil these obligations.

Once the proposed Programme is approved by the Engineer, the Contractor shall not depart from the Programme without written consent of the Engineer.

In the event of unforeseen difficulties or disturbances which shall have influence on the approved Programme of Works, he shall advise the Engineer in writing of such occurrences without delay and submit proposals for any necessary remedial measures, for which he shall obtain the Engineer's approval before putting such measures into effect.

The Programme shall clearly indicate the material approval dates before the order of such, the supplies' customs procedures, the working drawings submittals and the time of access to land, submittal and approval of road closing, the submittal of As-Built Drawings or any other event that may concern the Engineer.

When preparing the Programme of Works, as specified, the Contractor shall take account of the priority order prescribed for the various activities of the Works.

The Programme of Works shall conform to the following:

If it is necessary for the safety of the Works or for any other reason, the Contractor shall carry out such part of the Works continuously by day and by night when so instructed in writing by the Engineer.
The extent of the working site has to be agreed with the Employer and the Engineer. Generally, working sites shall be confined in accordance to physical restrictions and the requirements for maintaining vehicular and pedestrian traffic.

5.3.5 Cash Flow Programme

Together with the Work programme the Contractor shall provide to the Engineer a detailed Cash Flow Programme of all payments to which the Contractor shall be entitled under the Contract. He shall update this Programme with the updates of the Programme of Works, if required to do so by the Engineer.

5.3.6 Notices before Starting Excavation

The Contractor shall, before starting excavation in any portion of the Works, give all necessary notices and make timely and reasonable arrangements with:

The relevant Authorities for public roads (approvals for opening, agreements on resurfacing) and the Police (traffic arrangements), where applicable.
The statuary Authorities for water and energy supply and telecommunications (dealing with crossing of, maintaining and reinstatement of the respective services).
The concerned landowners (approvals of access, reinstatement of surfaces

5.3.7 Site Inspections before Starting Excavation

Before carrying out any excavation, the Site shall be inspected jointly by the Contractor and the Employer in order to verify site conditions, to establish the directions for site clearance and to clarify the further proceedings.

Before commencing any site clearance and excavation in private property, the Contractor shall prepare and agree with the owner or occupier of such property a record of the state of the surface with particular reference to any features that may require special care, conservation and reinstatement.

Preconstruction photos shall be taken of the original Site by the Contractor and be submitted to the Engineer in two (2) copies together with the respective digital files. By that way after construction the conserved and reinstated parts can be compared with the original status. The Contractor shall prepare an inspection report, which shall describe the conditions of the buildings, roads, footpaths etc. in question and shall submit such report to the Engineer.

Any damage caused by the Contractor to third party during excavation or other works shall be repaired and maintained by the Contractor at his own expense without any delay.

5.3.8 Technical Documentation of Manufactured Goods

The Contractor shall provide to the Engineer for approval a complete set of technical documents of all goods that shall be supplied from Manufacturers (pipes, valves, fittings, etc.) to be incorporated into the Permanent Works. The document shall further detail the documentation included in the Bid.

Only goods figuring in the technical documentation and approved by the Engineer shall be supplied.

The documentation of goods shall use the ID-system as set forth in the Particular Specification.

5.3.9 Construction Methods

The Contractor shall submit details of the plant, equipment and labour force, which he proposes to use and employ and shall describe in detail the proposed construction methods. The details on construction plant shall include the make, type, capacity or rating and the number of units, which the Contractor envisages to employ throughout the duration of the Contract.

Special attention shall be paid to the (1) procedure of concrete mixing, transporting, vibrating and curing and whether the concrete is prepared at the Site or elsewhere, (2) on-site coating, painting and other works serving for corrosion protection.

The Contractor shall furnish to the Engineer the formal approval of working methods he may be required to obtain from relevant authorities prior to the commencement of any new section of works. Such approval of working methods shall in no way relief the Contractor from his obligations.

Such approvals of working methods shall be obtained, as applicable, e.g. for the maintaining of public traffic, the dealing with/crossing of other services, the diversion of flow and discharge of water from excavations, the reinstatement of excavated areas and the provisions to ensure public safety.

5.3.10 Approval of Materials and Workmanship

The supply of all materials, items and accessories shall be subject to the approval of the Engineer.

The Contractor shall provide such samples as the Engineer may require in advance of the execution of Works for approval and, when approved, the quality of materials shall be at least equal to that of the approved samples. This includes also the testing and quality control of aggregates, cement and concrete and other building materials.

The Contractor shall furthermore provide sample areas and items of finished workmanship for approval by the Engineer as required by him. All workmanship shall be equal to the approved samples.

For the approval of materials standard institution certificates of the related materials from the country of production shall be submitted.

5.3.11 Testing of Materials

The Contractor shall provide material test results and certification by Independent Testing Laboratory approved by the Engineer showing that the materials meet the specified requirements. The testing of materials and goods shall be performed well in advance of the time they will be required for use.

The Contractor shall not be entitled to any compensation or claim for delays, inconveniences, damage, standing time or any other cause whatsoever, arising from the late submission of testing results or the rejection of materials and articles.

5.3.12 Setting Out of Works

Prior to the Commencement of the Works the Engineer shall provide a number of benchmarks on Site.

Before starting any work, the Contractor shall verify the levels of the benchmarks in the presence of the Engineer and shall request the Engineer to correct any omission or error which may be discovered during verification.

After the benchmarks and markers have thus been consolidated, the Contractor shall certify their acceptance in writing to the Engineer. The Contractor shall then establish, in locations and at levels approved by the Engineer steel datum pegs which shall be securely concreted in. The levels of these pegs shall be used as reference datum during construction.

The Contractor shall be responsible for accurate setting-out the Works, temporary benchmarks and shall carefully protect and preserve all benchmarks, sight-rails, pegs and other things used in setting-out the Works.

5.3.13 Survey Staff

The Contractor shall also provide all staff, labour, instruments and materials as may be required by the Engineer for survey work and measurements in connection with the Works.

5.3.14 Cost of Preparatory Works

The costs of all preparatory works as set forth in this chapter 2.3 shall be included in the corresponding items or in the items for Preparatory Works. Where items are not included in the Bill of Quantities for required facilities, the cost of such services, works and facilities shall be deemed to be included in the item “Site Installation and Preparatory Works”.

5.4 Disruption of Water Supply Service

Water services within the limits of the construction site will be operated by the Employer at any time and such services shall be considered as stipulated in chapter 2.2.8. However, when and where it becomes necessary for the execution of the Works to interrupt in order for the Contractor to replace or repair existing facilities, or connect existing facilities to the new system, herein called “Disruption”, then the Contractor shall only be permitted to use methods, types and numbers of equipment and levels of staff and labour which shall result in minimum Disruption.

The Contractor’s proposals for the execution of such works shall be subject to the Engineer’s approval, and the Engineer shall not be required to consider the costs to the Contractor (including payments for overtime to the Contractor’s personnel) or the convenience to the Contractor of particular sequencing of work, where such considerations conflict with the Employer’s need to limit the extent of Disruption.

The Contractor shall indicate in the Programme of Works, the approximate dates and durations of Disruption, and shall, during the execution of the Works, notify the Engineer forthwith of any circumstances which arise and may affect the expected dates of such Disruptions.

At least 14 days, before any Disruption, the Contractor shall submit to the Engineer for his approval his plan for works associated with the Disruption and details of date and duration intended for such Disruption. The Engineer shall within 7 days of such submission:

inform the Contractor of the dates and times when such Disruption will be permitted, which shall be not more than 3 days before or 7 days after the dates proposed by the Contractor;
approve the Contractor's plan or otherwise instruct the Contractor on the methods of work and types and numbers of equipment and labour to be employed on such works, and
provide the Contractor with the text of a notice by the Employer to the public of the intended Disruption.

The Engineer may otherwise instruct the Contractor that the Disruption shall take place on a date later than 7 days after the dates proposed by the Contractor.

Approval of a Disruption may be withheld at the Contractor's responsibility, if in the opinion of the Engineer the Contractor's proposal does not prove the adequacy of the measures in terms of quality and safety of the works and the duration of the Disruption. The Engineer shall notify the Contractor of such withholding of approval stating the reasons thereof, and giving instructions to the Contractor how to proceed.

The Contractor shall publish the Employer's notice on one and two days before the commencement of the Disruption in three national newspapers at a minimum of a quarter size.

The costs and effects of compliance with this Clause shall be deemed to have been allowed for in the Contractor's rates and prices.

6. EQUIPMENT AND MATERIALS

6.1 General

All materials required for the Completion of the Works shall be supplied in time and at the cost and under the responsibility of the Contractor

Only materials approved and accepted by the Engineer shall be supplied and installed. Materials which are rejected shall immediately be removed from the Site at the cost of the Contractor.

6.2 Pipes, Fittings and Joints

6.2.1 Supply of Materials

All pipes, specials, fittings and accessories supplied under the Contract shall be manufactured in accordance with the latest relevant EN Standards. For all items of supply the Contractor shall submit to the Engineer a certificate of compliance with the specified Standard. Where other Standards are proposed, they shall be equal or superior to the relevant EN Standard.

Uniformity of materials shall be maintained throughout the manufacturing process for each pipe size to the end, so that the test samples are representative of the entire output. All supplies shall be new, second-hand material shall be rejected.

The Engineer shall be empowered to reject any material, components and workmanship found to be inferior to the appropriate EN Standard and the Contractor shall make good the deficiency at his own expense.

Nomenclature, classification, symbols, conditions of manufacturing, characteristics and tolerances, conditions for the preparation of specimen, test rules, identification labels and acceptance clauses of pipes and pipe fittings must conform to the latest relevant EN standards.

All materials such as pipes, valves, fittings and other important components must display the following information:

The manufacturer’s name or mark,
The material identification such as ductile iron,
The identification of the year of manufacture,
The DN
The PN rating of flanges when applicable,
The reference to the Standard, in order to confirm that the material complies with the requirements.

6.2.2 Scope

Supply of material, as specified hereunder, shall include the transport from the Manufacturer’s plant to the site(s) indicated by the Engineer, handling, loading, unloading, intermediate storage sites and storage beside the trench in accordance with the supplier’s instructions and good workmanship.

The bid prices entered in the Bill of Quantities shall fully include the value of supplied material described under the several items and shall fully cover the cost of all labour, materials, tools, equipment etc. as necessary to furnish the material.

The payable length of the pipes corresponds to their useful length excluding sockets; fittings are payable per piece.

6.2.3 Potable Water Certification

All pipe and coating materials for water distribution pipes shall be certified for potable water use and shall contain no ingredients that might migrate into water in amounts that are considered to be toxic or otherwise dangerous for health by institutions approved by the Engineer. Compliance with this requirement shall be certified for each of the various kind of materials by an independent institution approved by the Engineer

6.2.4 Material required for connection to or branches from existing Mains or other Pipelines

The Contractor is obliged to determine the material and exact diameter of any existing pipe, to which a new pipe will be connected and shall submit to the Engineer a proposal for the intended transition pieces for approval before ordering the respective accessories. (The temporary excavation for searching / inspecting existing pipe shall be paid as set forth in the Particular Specification and in the Bill of Quantities).

6.2.5 Toxic Materials

The Contractor shall not import or use any toxic or poisonous grouts, for use in piping, its accessories, lining sealing etc., or in various kinds of concrete, soils or whatsoever.

6.2.6 Pipe Materials

6.2.6.1 General

Pipe materials shall be of the best quality of the class most suitable for working under the conditions specified and shall withstand traffic loads, operating pressure, corrosion and abrasion, and the variation of temperature and climatic conditions without distortion or deterioration or the setting of undue stresses in any part of the works and without affecting the strength or the suitability of the various parts of the work which they shall perform.

Where corrosion or abrasion may be expected from contact with water, sediments or from any other cause, the Contractor shall supply suitably resistant materials.

Any material showing signs of corrosion, distortion or pitting before expire of the maintenance period shall be replaced with material approved by the Engineer, at the Contractor's own expense.
The Contractor shall submit documentation on the details of the delivered goods; these documents shall bear the stamp and the signature of the manufacturer.

All pipes shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure and that normal storage, weathering handling, installation and use shall not affect the legibility of the marking.

6.2.6.2 Ductile Iron (DI) Pipes and Fittings

Ductile iron pipes and fittings shall be manufactured and supplied in accordance to EN 545. Any deviation from this standard shall be inadmissible and lead to rejection of the material.

Ductile iron pipes and fittings shall have spigot and socket ends where the seal is achieved by means of suitable retained rubber gasket (push-on). Wall thickness shall be K9 for pipes, otherwise as per 9.2 EN 545.

Rubber gasket materials shall comply with the requirements of EN 681-1, type WA. When materials other than rubber are necessary (e.g., for flanged joints), they shall comply with the appropriate European Standard (e.g., EN 1514).

For restrained joints, only type-tested double-chambered socket designs shall be used. Joint designs with counter-flanges or external collars and rods are not admissible. At steep alignments, non-positive locking devices are excluded.

For flanged joints (valves, air valves, dismantling joints etc.) stainless steel bolts, nuts and washers shall be used.

Flanges shall comply with EN 1092-2. Where flanged connections are covered by backfill, all flanged joints shall be wrapped in PE-sheets.

6.2.6.3 Steel Pipes and Fittings

Steel pipes shall be longitudinally or spirally welded and in accordance with EN 10220. Steel shall be low alloy St 37.0 acc. to DIN 1626. Pipes shall be supplied with an inspection certificate acc. to EN 10204 Table 1 and shall be suitable for PN 25 up to DN 600 and to PN20 for larger DN. Otherwise, DIN 2460 shall apply.

Pipes shall have the following wall thicknesses:

Pipe wall thickness								
DN	OD (mm)	T (mm)	DN	OD (mm)	T (mm)	DN	OD (mm)	T (mm)
80	88,9	3,2	250	273	4,0	500	508	5,6
100	114,3	3,2	300	323,9	4,5	600	610	6,3
150	168,3	3,6	350	355,6	4,5	700	711	6,3
200	219,1	3,6	400	406,4	5,0	800	813	7,1

Fittings shall be for butt-welding acc. to DIN 2605pp and DIN 2615pp, wall thicknesses shall harmonise with the PN of the adjacent straight pipe. Flanges for butt-welding shall be acc. to DIN 2632pp. All welds at main diameter exceeding DN 300 or PN 10 shall be subject to ultrasonic test.

The individual sections of manifolds shall be prefabricated in required lengths.

Pipes for laying as part of a trunk main shall be supplied with ends prepared for butt-welding of joints.

6.2.6.4 Polyethylene Pipes and Fittings

PE pipes shall comply with EN 12201. Pipes shall be of SDR 13,6, PN10.

The pipes and fittings shall be jointed in accordance with the diameters as set forth hereinafter.

PE granulate shall be of not less than PE 80 quality, be virgin and comply with German Health Authorities requirements (KTW-regulations). The Contractor shall provide such certificate for each 5000 m supplied from an institution appointed by the Engineer.

Any deviation from these prescriptions shall be inadmissible and lead to rejection of the material.
The pipe shall be coiled such that localised deformation, e.g., that buckling and kinking, is prevented. The minimum internal diameter of the coil shall not be less than 18 x nominal outside diameter. The ends of the pipe shall be plugged or covered.

No requirements have been set concerning particular lengths of coiled or straight pipe or the tolerance thereon; hence it is necessary for lengths of pipe to be supplied by agreement between purchaser and manufacturer.

Pipes of diameters less than DN 100 shall be joined with compression fittings of PE-HD, pipes of larger diameters shall be joined by butt fusion.

Fittings for diameters less than DN 100 shall be exclusively of compression type and of PE-HD or another appropriate approved plastic material and have bronze adaptors. Fittings for larger diameters shall be of butt fusion type.

Elastomeric materials used for the manufacture of seals shall conform to EN 681-1 or EN 681-2, as applicable.

The minimum required marking for PE-HD pipes shall conform to Standard Number; Manufacturer's Identification; Nominal diameter; SDR or k Series; Material and Designation; Pressure Rating in Bars; Production Period (date or code). All fittings shall be permanently and legibly marked in such a way that the marking does not initiate cracks or other types of failure. The minimum required marking for fittings shall conform to Standard Number; Manufacturer's Name or Trade Mark; Nominal Diameter and Pipe Series/SDR; Manufacturer's Information; SDR Fusion Range; Material and Designation.

6.2.6.5 Unplasticized Polyvinylchloride (PVC-U) Pipes and Fittings

All pipes, fittings and accessories shall be fabricated and supplied according to EN 1452-2 (pipes) and EN 1452-3 (fittings).

The pipe material to be used shall conform to EN 1452-1 and to the requirements given in chapter 4.2 and 4.3 of EN 1452-2.
Any deviation from these standards shall be inadmissible and lead to rejection of the material.

Pipes shall be of PN10 SDR21 for diameters less than 110mm, and of SDR26 for diameters above 90mm; the pipes and fittings shall be jointed flexible push-fit collar type with rubber gaskets.

PVC granulate shall be virgin and comply with German Health Authorities requirements (KTW-regulations). The Contractor shall provide such certificate for each 5000m supplied from an institution appointed by the Engineer

The fitting material to be used shall conform to EN 1452-1 and to the requirements given in chapter 4.2 and 4.3 of EN 1452-3

Fittings with flanges shall be of ductile iron, PVC- or epoxy-coated.

All PVC-U pipes shall have the following minimum required marking: Standard Number; Manufacturer's Name and/or Trademark; Material; Nominal Outside Diameter; Nominal Pressure PN; Manufacturer's Information (production period, year and name of the production site); Number of the

extrusion line (if not included in manufacturer's information). Fittings shall have the following required minimum marking: Standard Number; Manufacturer's Name and/or Trademark; Nominal Diameter; Material; Nominal Pressure PN; Manufacturer's Information (production period, year and name of the production site).

Flanges shall have the following minimum required marking; Standard Number; Manufacturer's Name and/or Trademark; Nominal Size DN of Flange; Material; Nominal Pressure PN of Flange; Manufacturer's Information (production period, year and name of the production site).

Pipes and fittings which conform to EN Standard, and conform to other standard(s) may be marked additionally with the number(s) of the other standard(s), together with the minimum required marking in accordance with the other standard(s).

6.2.6.6 Galvanised Iron (GI) Pipes and Fittings

Galvanised pipes and fittings (in accordance with the appropriate EN standards or equivalent standards) shall only be used as directed by the Engineer.

Galvanises iron pipes shall be manufactured according to DIN 2441 with threaded sockets in accordance with DIN 2441, ISO 65 or BS 1387, Heavy Series or similar with a spigot and a socket end.

The pipes shall be supplied threaded in accordance to DIN 2999 or BS 21, and shall have the screw threads clean, well cut and square with the axis of the pipe and be free from excessive burrs.

The end of each socket shall be chamfered internally.

The galvanisation shall be by hot-dip process according to DIN 1706 and shall satisfy the copper sulphate test procedure according to DIN 50952.

All pieces shall be straight, cleanly finished, free from cracks, surface flaw lamination and other defects and shall have a reasonably smooth surface. The overall pipe length, with one socket fitted, is to be 6 m plus or minus 150 mm.

6.2.7 Internal Lining and External Coatings

6.2.7.1 General

The Contractor shall provide detailed information and technical documentation of the internal and external protection of pipes. He shall specify the guarantee period of the coatings

All pipes and fittings shall be coated at the manufacturer's works. The metal surface shall be free of corrosion prior to application of coating to guarantee maximum adherence of the coating.

Internal lining of pipes and fittings shall be certified for use for potable water. Internal lining shall guarantee that the hydraulic performance of the pipes and fittings shall be maintained long term even if the water shall be aggressive.

In general, the quality of internal lining and external coatings shall be excellent upon delivery. The Engineer shall not accept pipes with damaged lining and coatings.

6.2.7.2 Ductile Iron Pipes and Fittings

Ductile iron pipes and fittings shall have coating and lining in accordance with EN 545 as follows:

Pipes, external coating: rich metallic zinc plus bituminous paint
Pipes, internal lining: cement mortar of blast furnace cement
Fittings, external coating bituminous paint or epoxy
Fittings, internal lining cement mortar of blast furnace cement or epoxy
Polyethylene sleeves for field application, as directed by the Engineer

Thickness of cement mortar lining		
Diameter	Nominal thickness	Minimum thickness
DN 80 - DN 300	3,0 mm	2,0 mm
DN 400 - DN 600	5,0 mm	3,0 mm
DN 700 - DN 1200	6,0 mm	3,5 mm

6.2.7.3 Steel pipes and fittings

Shall be read as follows:

Steel pipes and fittings to be installed in plant or in manholes or buried as part of welded manifolds of system points shall receive their coating and lining in the manufacturer's works prior to shipping. Coatings inside and outside as follows:

Sand blasting to SA 2 ½ acc. to EN ISO 12944 part 4 and free of dirt, oil, grease
1 shop coat of 2-component high-pigmented rich zinc epoxy primer of low solvent content, 20micron as primer, weldable (Friazinc R or equivalent)
1 site coat of the same primer, 60-micron, spray application (Friazinc R or equivalent)
2 finish coats of solvent-free 2-component epoxy resin, 225 micron each (Icosit TW1 or equivalent last coat colour blue RAL5015)
.
Steel pipes and fittings to be laid in pipe trenches as part of a main shall have the following lining and coating:

Pipes and fittings, external coating: rich zinc paint and extruded PE-lining, blue colour
Pipes and fittings, internal lining: cement mortar of blast furnace cement.

Thickness of cement mortar lining		
Pipe diameter	Nominal thickness	Minimum thickness
DN 80 - DN 300	3,0 mm	2,0 mm
DN 400 - DN 600	5,0 mm	3,0 mm
DN 700 - DN 1200	6,0 mm	3,5 mm

Internal lining shall end 10 mm before the butt-welding end.

PE-sleeves for application by shrinkage and rich zinc paint shall be provided for field-coating and wrapping after butt-welding.

6.2.7.4 Galvanised Steel Pipes

Standard reference is NF 49.700 or equivalent. Pipes and fittings shall be hot dip galvanised.
The zinc mass on the pipe shall be minimum 4 g/dm^2 per side. The coating shall be homogeneous.

6.2.8 Pipeline Appurtenances

6.2.8.1 Bolts, Nuts and Washers

All bolts and nuts necessary for assembly shall be supplied together with the equipment. The Contractor shall supply an extra 20% of this assembly material as reserve. The cost of the assembly material + reserve shall be included in the unit price of pipes and fittings.

Bolts and nuts shall comply as a minimum with the requirements of EN ISO 4016:2000 and EN ISO 4034:2000, grade 4.6. Washers shall comply with EN ISO 7091. All bolts, nuts and washers used for flanged connections shall be of stainless steel.

6.2.8.2 Dismantling Joints

Dismantling joints shall be provided according to DIN 2541 or DIN 2547 or flange adapters as indicated on drawings or directed by the Engineer. Flanges to EN 1092-2, PN10/16

If not otherwise directed, body and glands of steel welded dismantling pieces shall be of pressure class PN 16 with bolts and nuts of stainless steel.

Surface protection shall be of one primer coat and two component epoxy resin coats. PE-sleeves for application by shrinkage and epoxy paint shall be provided for field-coating and wrapping after installation.

Rubber sealing rings made of perbunan material; nitrite rubber or equivalent quality material shall be used.

6.2.8.3 Flexible Couplings and Flange Adapters

Flexible couplings and flange adapters shall be of low alloy carbon steel and of an approved type suitable for making a watertight flexible connection.
Surface protection shall be of one primer coat and two component epoxy resin coats. PE-sleeves for application by shrinkage and epoxy paint shall be provided for field-coating and wrapping after installation.

All mechanical couplings shall be of appropriate internal diameter, shall allow a joint deflection of up to 4° in any direction and longitudinal movements up to 9 mm. and shall be capable of withstanding the maximum working test pressure specified for the pipes they are to connect.

Flange adapters shall be capable of providing half of the flexibility of the couplings. Sliding action shall not provide the horizontal movement. It shall occur by deforming of the sealing rings.

All mechanical couplings and flange adapters shall be supplied complete with all necessary coupling rings, nuts, bolts, washers and rubber rings.

Wedge joint rings shall comply with EN 681-1 or EN 681-2 and shall be made of nitrite rubber, ethylene propylene rubber or other approved materials. The sealing shall be resistant against corrosive water and wastewater.

6.2.9 Shipping, Packaging, Protection

PVC-U, PE and galvanized steel pipes and other equipment shall be shipped in 20 ft welded containers only. The containers shall be one-way containers and shall become the property of the Client. Pipe lengths shall be adapted to the containers' clear length.

PVC-U, PE and galvanised steel fittings shall be packed in wooden cases in bulk or individually protected and transported in 20 feet containers. Jointing material shall also be packed in wooden cases.

DI pipes and steel pipes shall be bundled (< 300mm) with wrappings suitable for conditions of transport and adequate protection, in order to facilitate handling and storage. DI and steel pipes with DN >300mm shall not be bundled. Ductile iron pipes shall be delivered with a plastic stopper at each end.

DI fittings shall be packed on non-returnable pallets and covered with two sheets of plastic film and transported in 20 feet containers. Bolts and nuts shall be supplied in boxes.

Each package of fittings shall have at least one label with the manufacturer's name, type and dimensions of the part of units and any special storage conditions.

Unless specified otherwise, containers shall be sealed on leaving the factory and opened only at their final point of destination, without opening of the packaging at the port of arrival. Containers therefore shall bear distinctive labels specifying the project they belong to.

6.2.10 Handling and Storage of Pipes

6.2.10.1 Handling and Transport of Pipes

The Contractor's arrangements for handling, lifting and transporting of pipes, fittings, valves and other appurtenances shall ensure that these appurtenances are brought to their final place on site undamaged and in good order.

Handling and storage on Site must conform to manufacturer's recommendations and standards. Open-air interim storage of ductile iron pipes is permissible if proper positioning is maintained; PVC-U and PE must be protected against sunlight.

Pipes, fittings and appurtenances shall be handled with utmost care and the Contractor shall provide cranes and other appliance approved by the Engineer wherever it is necessary to lift or lower pipes or pipe specials.

For the handling of pipes with external coating and lining, slings of canvas, rubber belting or special fittings shaped to fit the pipe ends shall be used. Hooks shall not be used for lifting of pipes nor shall pipes be dropped or dragged.

Ductile iron pipes being transported, shall be supported by timbers, sand bags or padding arranged in such a way that the pipes do not rest on their sockets but on their barrels and that adjacent pipes do not touch.

The height of the load for the various pipe diameters shall not be more than prescribed by the manufacturer and approved by the Engineer.

Ropes or other lashing arrangement shall secure each load so that the pipes do not move or chafe and suitable padding shall be used to ensure that the pipe coating is not damaged by these lashings.

Pipe specials shall be supported by sandbags or other padding and lashed down as described above so that they are not damaged during transport.

6.2.10.2 Storage on Site

All materials provided by the Contractor shall be stored in a proper storage area subject to the approval of the Engineer.

The Contractor shall foresee a fenced and lockable compound in which all fittings, valves and other pipe appurtenances are to be kept, and also maintain shelters of sufficient size and capacity to store the materials and to protect them from the effects of weather always in accordance with the manufacturer's prescriptions.

The Contractor shall be responsible for cleaning, levelling and enclosing the storage site and shall provide all necessary security.
The Contractor shall at all reasonable times allow the Engineer or the Employer free access to any place for inspection and testing.

In all cases the Contractor shall satisfy the Engineer that all material has been delivered in good and clean condition, identification markings shall be clear and stock piling shall be in approved manner.

The Contractor shall keep detailed records in a format approved by the Engineer of all pipes, fittings, valves and other pipe appurtenances, showing the quantities of each type and class which have been

Received by the Contractor during the course of the Works;
Broken, damaged or lost during the course of the Works;
Found to be surplus to the requirements and held by the Contractor.

Such records shall be updated and delivered by the Contractor to the Engineer on a monthly basis.

The Contractor shall comply with the Engineer's instructions as to the disposal, repair or replacement of any pipe, fitting or valve which has been notified as being faulty, damaged or missing.

6.2.10.3 Stacking of Pipes

The Contractor shall properly stack the pipes in storage yards at Site(s) and the stacks shall be laid out in regular pattern as prescribed by the Manufacturer. The limits of each stack shall be marked so that the movement of cranes and vehicles shall be restricted to access tracks between the stacks and the control of delivery and removal of pipes is facilitated.

Where the pipes are to be delivered and stacked on designated sites along the pipeline route, the areas where the pipes are to be stacked shall, if directed by the Engineer, be graded flat by the Contractor at his own expense to provide a firm and even surface and be kept free from loose stones, rubbish or waste liable to damage pipe coating.

Material delivered will be accepted only if proper storage provisions have been made and if equipment which was damaged during shipment, is either repaired or replaced.

6.2.10.4 Distribution at the Site

In distributing the material at the site of works, each piece shall be unloaded adjacent or near to the place where it is to be laid. Rubber rings for pipe joints shall be stored and protected in an appropriate manner to prevent deterioration.

The Contractor shall keep the pipe and the appurtenances clean during the progress of the Works. Dirt, debris or other foreign material shall be removed from the interior of the pipe and the joints before installation.

6.3 Valves, Air Valves, Hydrants and Control Equipment

6.3.1 General Requirements

All valves shall be flanged, if not specified otherwise. All flanges of valves shall conform and satisfy the requirements of EN 736 1-3 and be in accordance with the required test pressure of EN 764.

The face-to-face and centre-to-centre dimensions of flanged valves shall comply with EN 558-1 and EN 558-2, respectively.

Extended spindles and accessories (coupling, cap, extension tube, surface box) and headstocks, if required, shall be provided where necessary and were indicated on the Contract Drawings. Headstocks shall be provided in stainless steel.

All shut-off devices shall close clockwise. This shall be indicated by 'O' (open) and 'C' (closed) with arrows either on the hand wheel or the head of a piece. Operation of shut-off devices must be easy both for opening and closing.

Manufacturer's marks, flow diameter and an arrow indicating flow direction must be visible on the device's outer surface.

Punched or forged special elements shall have this information stamped upon them.
Before materials are accepted or used the Contractor may be required to submit to the Engineer a sample piece of every hydraulic equipment, fitting, valve and accessory for approval.

The following test pressures are stipulated:

Nominal Pressure	Test Pressure	
	Body	Tightness
6 bars	10 bars	6 bars
10 bars	16 bars	10 bars
16 bars	25 bars	16 bars

One key and one extra hand wheel shall be provided for each type of valve delivered and installed in the system. The keys and hand wheels shall be included in the unit rates.

6.3.2 Gate valves

Gate Valves shall comply with EN 736 1-3.

Gate valves installed in chambers and buried shall be double flanged of series 14 and 15, respectively, of EN 558-1.

Body and obturator shall be of ductile iron EN-GJS-400-18 acc. to EN 1563 (GGG 400 - DIN 1693). of PN 16 with screw-less bonnet, pressure loaded and pressure sealed with easy assembly and dismantling of functional parts. Obturator shall be elastomer-coated, thread of stem rolled, not cut.

All jointing material and rubber ring gasket or adaptors shall be provided by the contractor as necessary to connect the valve with the adjoining pipe material, without incurring any additional cost.

Buried valves shall be supplied with stem nut coupling, sleeves and extension spindles of 0.5 m and 1.0 m length according to the requirements on Site. The extension spindles shall be made of hot dip galvanised iron, coupling sleeves of galvanised ductile iron, connection pins of Cr and Ni steel.

Where required, length of spindles shall be adjusted. The top of the extension spindle (key rod) shall be fitted with cast iron surface box according to DIN 4056 with pre-cast concrete support of 380 mm diameter and 65 mm thickness. A suitable PE guard tube including cover shall protect the spindle itself.

Valves to be installed above ground or in valve chambers shall be provided with hand wheels of cast iron. Hand wheels shall have smooth rims and have a diameter to enable two men to operate the valve. The direction of opening and closing shall be marked on the hand wheel.

(Reference model: VAG Beta 200 or Erhard Mutamed)

6.3.3 Butterfly Valves

Butterfly valves shall be in according to DIN and EN 593, double eccentric type with face-to-face dimensions to EN 558-1 GR 14-short (DIN 3202-F4), flange dimensions and drilling to EN 1092-2 PN 16 (DIN 28605 / DIN 2501).

Body and disk shall be of ductile iron EN-GJS-400-18 acc. to EN 1563 (GGG 400 - DIN 1693).
Shaft, body seat, bolts and pins shall be made of stainless steel 304 (minimum 1.4021) (or 316 (minimum 1.4462).
Endless profile sealing ring and O-rings shall be of EPDM or NBR suitable and approved for potable water. Drive mechanism of butterfly valves shall consist of a ductile cast iron casing with a crank or worm gear consisting of a bronze nut and a steel worm. Grease shall be provided for lifetime of the valve.

Butterfly valves installed below ground shall have the same underground equipment as the gate valves; those installed above ground or in manholes shall be hand wheel-operated.

(Reference model: VAG EKN or Erhard Roco

6.3.4 Air Valves

Automatic air valves shall be able to perform the following functions:

Aeration / vacuum breaking of large quantities of air to prevent excessive sub-atmospheric pressures
De-aeration of large quantities of air in a pipe at atmospheric pressure during initial filling of a pipe

De-aeration of small quantities of air under full internal system pressure for air that dissolves from the water at points of low pressure

The air valves shall be suitable for reasonably clean and cold water. The basic operating principle shall comply to a kinetic air valve. It shall be suitable to operate with special gasket at internal pressures as low as 0.1 bar. In operation the discharge differential pressure shall be limited to 0.05 – 0.07 bar or a maximum velocity of 30 – 40 m/s to prevent pressure surges.

Automatic air valves shall have a single chamber and be directly operated by the flow medium. It shall have a large orifice for outlet and intake of large air volumes and a small orifice for discharge of pressurized air during service. The float shall be stabilised in a guide basket permitting high venting capacity. Standard double chamber air valve with ball-type floats are not allowed.

The body and lid shall be of ductile cast iron GGG-40. The float, the shell, bolts and nuts shall be stainless steel.

(Reference model: VAG Duojet)

6.3.5 Corrosion Protection of Valves

All valves shall be internally and externally lined and coated by epoxy powder applied hot by electro-static method. complying in general with DIN 30677 Part 2, coating thickness shall be minimum 250µm. Coating shall be tested by high-voltage method for perfect cover.

6.3.6 Fire Hydrants

6.3.6.1 Pillar Hydrants

Pillar hydrants, shall conform to EN 1074-1 and EN 1074-6.

The hydrant shall be connected to the water supply system including an isolating valve and be fitted with an inlet flange in accordance with EN 1092-2 and shall have two (2) outlets suitable for the connection of hose pipes, screw type.

The hydrant shall have a closed casing and cover, a valve with automatic discharge device, suspended connection piece flanged lateral or vertical to feeding pipe. The hydrant shall be installed according to drawing and as directed by the Engineer.

Hydrant bodies shall be of grey cast iron or ductile cast iron and shall be properly corrosion protected by painting according to DIN 1843.

Hydrant spindles shall be of stainless steel. Spindle nuts and body seating shall be of gunmetal or high tensile brass. Valve seats shall be of the resilient type.

Hydrants shall show no visible leakage when pressure tested in accordance with the approved standards.

6.4 Accessories

6.4.1 Manhole Covers

Lockable cast iron covers with frames shall be installed for all chambers as specified or shown on drawings. The wording on each cover shall be agreed with and approved by the Engineer prior to ordering.

Covers to be used in surfaces, which are subject to vehicular traffic, shall be Class D, according to EN 124.

Two pairs of keys for use with each type of cover shall be handed over by the Contractor after completion of Works at no extra cost.

6.4.2 Indicator Plates

Indicator plates shall serve to mark DN and locations of valves of mains. Locations shall be indicated by x,y offset originating from the location of the plate. Each unit shall consist of a plate and the letters and figures that shall be fixed to it. Letters and figures shall be 50mm high and be of Latin and Arabic character, respectively.

Plate, letters and figures shall be of weather-proof plastic, the plate of grey and the characters of dark-blue permanent colour. The characters shall be permanently fixed to the plate. The Contractor shall propose a proven system, e.g. Acc. to DIN 4067.

6.4.3 Marker Tapes and Protective Tapes

6.4.3.1 Marker Tapes

Marker tapes shall serve to mark location of mains in the ground and allow detection by all standard and advanced detection methods using conductors. Tape shall satisfy the requirements of DIN 54841-3, be of PE and be fitted out with two copper conductors, one isolated and one blank and in contact with backfill. Thickness shall be not less than 0,15 mm and width shall be 80 mm, colour shall be blue. The tape shall be supplied in coils of 250 m.

6.4.3.2 Protective Tapes

Marker tapes shall serve to mark location of pipes in the ground and to prevent unforeseen uncovering and damage to the pipe. Tape shall satisfy the requirements of EN 12613. Thickness shall be not less than 0,25 mm and width shall be 50 mm, colour shall be blue. The tape shall be supplied in coils of 250 m.

6.5 House Connections and Public Taps

6.5.1 House Connections

For standard house connections the following material shall be used:

- Tapping saddle with threaded joint to service pipe
- Corporate stop cock for buried installation in the service pipe
- Service pipe of PE material
- Multiple jet water meter

- Upstream stop cock
- Meter box

All material shall be tested at 16 bar for body and 10bar completely assembled.

6.5.1.1 Service Connections

Customer Connections shall be installed with materials as specified, according to EN Norm.

Connections to the distribution system shall be made with pipe saddles corresponding with the main pipe's material and outside diameter.

Drillings shall be made with special equipment, specially designed pipe drilling machines for under pressure drilling.

The cover of the connection pipe shall be 90 cm minimum, if required the connection has to be lowered to the required depth.

The Customer Water Meters shall be generally installed inside a compound (compound border), in a prefab chamber as specified. The water meters shall be sealed with a copper wire and lead seal.

6.5.1.2 Pipe Saddles

Pipe saddles shall be of the Universal Type with flexible strap for DI, DCI, Steel and AC pipes PN 16, for PVC-U pipes the pipe saddles shall be of the HAKU Type or similar, and shall be suitable and approved for the use with potable water at a nominal working pressure of 16 bar.

The outlet of the saddle shall be female thread and specially protected to avoid corrosion and incrustation.

The body of the pipe saddle shall be of ductile iron EN*-GJS-400-18 acc. to EN 1563 (GGG 400 DIN 1693), inside and outside epoxy powder coated complying in general with DIN 30677 part 2, coating thickness shall be minimum 250µm, freedom from imperfections shall be tested by high-voltage method.

Saddle strap and bolts/nuts/washers shall be made of stainless steel 304 (minimum 1.4021) or 316 (minimum 1.4462). Strap shall be rubber lined to avoid direct contact between the stainless-steel strap and the pipe.
Gaskets shall be of EPDM or NBR suitable and approved for potable water.

6.5.1.3 Service Valves (Stop Cocks)

Service Valves shall be suitable for a direct installation in the service pipe and shall allow a temporary shut-off of the house connection line in case of emergency.

Service valves shall be of the resilient seated gate valve type with integrated or adopted restraint push-on outlets for connection to PE pipes and female threads for GMS pipe connection, and shall be suitable and approved for underground installation and for the use with potable water.

Valve bodies shall be of GG 250, the bonnet of GGG 400, epoxy powder coated, and non-rising stainless-steel spindle (1.4021). The sealing of the restraint socket for connection to PE pipes shall be

done by an O-ring made from EPDM or NBR (suitable and approved for potable water), grip ring shall be of Poly-acetate.

The service valves shall be installed with an appropriate Extension Spindle made of steel with PE-protection tube to the street surface, additionally protected by a PVC pipe and a service valve surface box (cast iron).

6.5.1.4 Water Meters

Domestic water meters DN 20 (3/4") shall be of dry dial multi-jet meter type, metrological class B and shall be approved according to EEC 75/33 standards.

Domestic water meters for DN 25 (1") to DN 50 (2") shall be of the multi jet full dry meter type, metrological class B and shall be approved according to EEC 75/33 standards, PN 10 (or PN 16). Housing for those meters (DN 25 to DN 50) concerning WVG. Internal filter must be exchangeable without dismounting the meter.

Roller counter design for multi jet meters: 5 digits black, 4 pointers red and one low flow indicator.
Roller counter repairable. Roller counter further prepared for afterward installation of Reed- or Radio modules.
All materials shall be anti-magnetic and not corroding Both turbine and clock shall be fully and easily interchangeable without dismantling of body.

Meters shall be supplied with male threads acc. to EN 228 and female sockets.

The meter shall be equipped with a non-return valve and a strainer. Both strainer and check-valve shall be detachable without braking of the seal.

6.5.1.5 Stop Cocks Downstream of Meters

These stop cocks shall have spherical obturator with integrated passage at quarter turn opening. Material shall be as follows:

Body:	brass
Obturator:	anti-lime deposit material or metal with anti-lime lining
Seals:	Teflon© or Perbunan©
Stem:	brass
Handle:	brass

6.5.1.6 Water Meter Box

The meter box shall be large enough to house the meter and a stop cock on either side and shall have 50cm useful depth. Test load shall be not less than 100kN. The cover shall be made of durable glass fibre reinforced resin, the barrel and bottom of glass fibre reinforced thermoplastic material. The cover shall have an extra 50mm thermal insulation of polystyrene, a second cover of same kind shall be placed above the meter. The cover shall close tight against surface water and dust. The mass shall not exceed 20kg. Box shall include a bracket to hold the meter and the adjacent stop cock.

6.5.2 Public Taps

Public Taps shall be constructed in accordance with the relevant contract drawing.

7. CIVIL WORKS

7.1 Earth Works

7.1.1 General

7.1.1.1 Works Included

Earth Works as specified hereunder shall include the location of underground structures, the preparation of the site including protective fencing, excavation including strutting, sheeting, bracing and protection of slopes, trimming, disposal of excavated materials off site, backfilling including delivery of backfill material and site clearance including disposal of surplus material.

7.1.1.2 Unit Prices to include

The bid prices entered in the Bill of Quantities shall fully include the value of Works described under the several items and shall cover the cost of all labour, subsidence, travelling, materials, fittings, temporary works, constructional plant, watching, lightening, overhead charges and any other expenses whatsoever together with all risks, liabilities and obligations set forth or implied in the Contract Documents.

7.1.1.3 Standards

The Contractor shall carry out works described in this Specification in accordance with the appropriate EN and DIN Standard. These are, but are not limited by, the following:

EN 1610	Construction and testing drains and sewers
DIN 4124	Building pits and trenches
DIN 18300	General technical codes for earthworks
DIN 18303	General technical codes for excavation lining.

The Contractor may carry out the works or provide materials in accordance to local or other international standards (ISO, DIN and others), provided their requirements are superior or equivalent to the quality described by the standards cited in the Specifications.

7.1.1.4 Classification of Soils

The following terms shall apply to Specification Clauses in which reference is made to the excavated materials:

Topsoil means any surface material suitable for use in soiling areas to be grassed or cultivated (Class 1, DIN 18300).

Subsoil any material other than topsoil and rock shall be classified as “subsoil “(Class 2-6, DIN 18300).

Rock is defined as material occurring in solid un-weathered banks or layers which, in the opinion of the Engineer, can only be removed by blasting, percussion drilling, wedging or splitting. Boulders exceeding 1 m^3 in volume shall be classified as “rock “(Class 7, DIN 18300).

7.1.1.5 Excavation Methods

The following terms shall apply to Specification Clauses in which reference is made to excavations:

Normal Excavation means excavation in open cut (excluding trench excavation) down to levels specified on drawings or otherwise as being the general levels after completion or excavation other than incidental excavation.

Trench Excavation means excavation, to levels and limits specified on drawings or otherwise, of trenches in which pipes or the like are to be laid.

Incidental Excavation means excavation in small quantities below or outside the limits of normal excavation and trench excavation, but excluding excess excavation.

General Excavation means excavation, whether normal or incidental, required for structures, roadwork and borrows areas.

Excess Excavation means excavation outside the limits specified for normal, trench or incidental excavation. Excess excavation shall not qualify for any extra payment.

7.1.1.6 Backfill Materials

The following terms shall apply to Specification Clauses in which reference is made to backfilling of excavations:

Unsuitable Material means material not suitable for backfilling including materials from swamps, organic and perishable materials, clay and soils with high placidity indices such as liquid limit (LL) > 80 and plasticity index (PI) > 55.

Rock Fill shall consist of hard unweathered material of suitable size for deposition and compaction and may comprise broken stone, hard brick, concrete or other hard inert material.

Selected Fill for backfilling trenches and foundations shall comprise well graded readily compactable material free from roots, vegetable matter, building rubbish and clay lumps.

7.1.2 Excavation

The Contractor shall examine the site and familiarise himself with the nature of ground, the excavation methods to be applied and physical obstructions that may affect the work. The use of explosives shall not be permitted.

The Contractor shall not execute any excavation without having the Engineer's prior approval to the methods, which he proposes to employ. The Contractor shall not modify such methods thereafter without the Engineer's consent.

7.1.2.1 General Excavation

General excavation, whether normal, mass or incidental excavation, required for structures and roadwork shall be carried out to the grade of the bottom of the structure.

General excavation shall be carried out after site clearance and the stripping of topsoil.

In the working drawings, the Contractor shall indicate the limits of excavations to be made for the construction of the individual structures.

The prices quoted for general excavation shall be fully inclusive and contain all incidental works as:

Excavation of any type of ground including rock, whether this excavation has to be made by hand or by machine;

Location, maintaining and reinstatement of existing services, where required;

Supporting excavations and temporary support of the sides of excavations;

Keeping free the excavation from surface and ground water;

Trimming, compacting and protecting of formation levels;

Any additional excavation to accommodate temporary supports and all working space to carry out the work;

Disposal of excavated material whether it shall be reused for backfilling or removed as surplus material off site including formation of all temporary spoil heaps and all double handling necessary;

Protection of the works and all additional measures necessary to ensure that the dug is maintained in a safe and workmanlike manner.

Demolition of existing surfaces and underground structures shall be paid separately.

7.1.2.2 Trench Excavation

Trench excavations shall be carried out in accordance with EN 1610.

Trench excavations for pipes and interconnections shall be open-cut trenches with minimum width, as defined below. All pipes sewers and cables shall be laid in trenches excavated in undisturbed soil.

The trench shall be excavated to such depths as necessary to permit placing pipe bedding material or concrete encasement as required and to allow the pipe to be laid at the required elevations, slopes and depths. Trench bottoms shall be cleared of projections such as rocks stones roots and the like.

The width of the trenches in accordance with EN 1610 shall be deemed sufficient to permit the pipes to be laid and jointed properly and to place and compact the backfill as specified.

Trenches for all kinds of pipes shall be excavated to 150 mm below the bottom of the pipe as required to accommodate for adequate bedding.

7.1.2.3 Further and Excess Excavation

When the specified levels or limits of excavation are reached and approved by the Engineer, he will inspect the subsoil exposed and may, if he considers any part of the subsoil unsuitable, direct the Contractor to excavate further. Such further excavation shall be refilled to the specified levels or limits with approved imported material or concrete class C 8/10.

Any excess excavation outside the specified "payment limits" and any further excavation which has not been ordered by the Engineer shall be held to be excess excavation which shall not be paid for.

The Contractor shall, at his own expense, remove from the Site all material resulting from excess excavation and shall make good the same with such kind of fill material or concrete as may be reasonably required by the Engineer having regard to the circumstances.

7.1.2.4 Keeping Excavations Free from Water

The Contractor shall keep all excavations free from water and sewage, whether caused by floods, storms or otherwise, so as to construct the works in dry conditions.

The Contractor shall keep infiltrating or accumulated water at a level lower than the bottom of the permanent work for such a period as required by the provisions of the Specification and the Contractor's method of construction.

The mode of drainage proposed by the Contractor is subject to the approval of the Engineer. Any sub-drainage below the permanent works shall, if left in place, be sealed with concrete or other approved material. Sub-drains underneath permanent concrete structures shall be covered with waterproof membranes.

7.1.2.5 Trial Holes

The Engineer may direct that trial holes shall be excavated well ahead of excavation to such depths, as he shall order to determine the location of existing works. Such excavation shall be held to be incidental excavation.

7.1.2.6 Supporting Excavations

The Contractor shall support the sides and the ends of all excavations to prevent any fall or run from any portion of the ground outside the excavation and to prevent settlement or damage to structures adjacent to the excavation.

The Contractor shall provide, install and maintain all materials necessary to provide such support.

If, for any reason, any portion of the bottom, sides and ends of any excavation shall give way, the Contractor shall take all necessary remedial measures including the excavation and removal of all the subsoil thereby disturbed at both, inside and outside the nominal limits of excavations.

Where the Contractor proposes to perform excavations with sloping faces and without shoring, the excavated faces shall be to stable slopes and heights. Full details on the execution shall be submitted to the Engineer for approval.

7.1.2.7 Shoring

When the material being excavated has sliding planes inclined towards the trench, adequate shoring must be carried out immediately after excavation. Particular care shall be taken if the earth, though firm, may be rendered unstable when trenched or by rain or seepage of groundwater.

If slipping or collapsing of the sides unavoidably increases the width of the trench, work shall be suspended and the Engineer informed on the occurrence. The Engineer shall decide, whether the design of the pipeline has to be reviewed in view of trench width or, if necessary, the class of bedding and shoring.

The method of shoring to be used is up to the discretion of the Contractor, but subject to the approval of the Engineer with regard to safety. The Contractor shall be fully responsible for the stability and the effectiveness of the shoring. Costs for shoring shall be included in the rates and prices entered for other items in the Schedule of prices.

The method statement shall include Engineering calculations for the sheeting, shoring and piling for different excavation depths.

7.1.2.8 Measurement of Excavations

After levelling and clearing the site under the Works, the Contractor shall take and record levels of any such part, in the manner specified or as agreed by the Engineer. Such levels, when agreed by the Engineer, shall be the basis for measurement. The Contractor shall also take and record such other levels and dimensions as are necessary during the process of excavation.

Any kind of excavation shall be measured in situ.

General excavation: Where normal payment limits of general excavation are not shown on drawings or not otherwise specified, they shall be deemed to be the minimum net limits which would allow the outline of the completed structure to be lowered vertically from subsoil level into its final position. In such case, the Contractor shall make his own allowances for the working space required and the backfilling of such space.

Trench excavation: shall be measured net, whereby the minimum width of trenches as stated in this Specification, the depth to the specified level including excavation for bedding and the length of services laid (linear meters run as specified for pipe laying) shall be taken as payment limits.

Excavations required joint holes, anchorage, manholes, chambers and all auxiliary works shall not be measured separately and are deemed to be included in the unit price for excavation.

The preparation of sites and pipeline route including clearing, grading, stripping of topsoil and demolition of paved surfaces shall be measured separately.

7.1.2.9 Payment for excavation

The prices quoted for trench excavation shall be fully inclusive and contain all incidental works such as, but not limited to:

Excavation of any type of ground including rock, whether this excavation has to be made by hand or by machine;

Excavation below groundwater level irrespective of depth;

Location, maintaining and reinstatement of existing services and ditches, where required;

Excavation for joint holes, fittings, thrust blocks, encasements etc.;

Sheeting and piling of trenches, respectively bracing and protection of slopes;

Levelling, trimming and consolidating the bottom of the trench;

Keeping of trenches free from water and maintenance of flow during construction;

Additional excavation to accommodate temporary supports and all working space to carry out the work;

Disposal of excavated material whether it shall be reused for backfilling or removed as surplus including formation of all temporary spoil heaps and all double handling necessary;

All additional measures necessary to ensure that the dug made to the correct line and level and maintained in a safe and workmanlike manner.

Payment shall be made acc. to the quantities measured and the pay items of the Bill of Quantities

7.1.2.10 Disposal of Excavated Material

Disposal of excavated material shall be to the Contractor's discretion subject to the approval of the Engineer and shall suit the overall requirements for the execution of the Works.

7.1.2.10.1 Disposal on Site

Excavated material shall be disposed within the Site in any of the following ways:

Transporting and placing in temporary stockpiles and backfilling to excavations including any double handling of materials; or
Transporting and placing of approved materials in permanent stockpiles, including the shaping and drainage of such tips; or
Transporting of selected excavated materials to locations within the site for embankments and filling around structures including tipping for spreading and compaction.

7.1.2.10.2 Stockpiles on Site

Only such materials approved by the Engineer shall be placed in the various stockpiles. No tree trunks, stumps, roots, foliage or rubbish of any kind shall be placed in stockpiles.

Temporary stockpiles to store excavated materials shall be arranged by the Contractor. Such stockpiles shall be shaped as to maintain stability and good drainage at all times. Topsoil stripped from the Site shall be stored in separate stockpiles for later use in reinstatement and landscaping.

7.1.2.10.3 Disposal of Excavated Material Off-Site

Excavated material, which is not required or not suitable for reuse in the Works shall become the property of the Contractor. The Contractor shall dispose such material Off-Site at locations to be determined by the Contractor. Such locations shall be in accordance with the regulations of NEMA (National Environment Management Authority) and be approved by the Employer.

7.1.3 Backfilling

7.1.3.1 Materials

7.1.3.1.1 Backfill Material

Selection of backfill material is subject to the approval of the Engineer. Fill material shall be, if not specified otherwise, selected and / or crushed so that the maximum grain shall not exceed one half of the thickness of the layer for compaction and that it shall have a continuous gradation allowing for easy compaction. For trenches, the maximum grain size shall not exceed 50mm.

Fill material shall be free of organic, soluble or other deleterious materials.

Should the material selected as backfill become unacceptable to the Engineer for any reason including exposure to weather conditions, contamination and segregation during the progress of the Works, the Contractor shall remove such damaged, softened or segregated material and replace it by fresh approved material at his own expense.

7.1.3.1.2 Sand Embedment

Any kind of pipes and cables shall be laid on and embedded in compacted bed of sand or approved excavated material in accordance with EN 1610. Sand and/or approved backfilling materials from different sources of supply shall not be mixed or stored in the same pile nor used alternately in the same class of construction without the permission of the Engineer.

7.1.3.2 Graded Aggregates

Graded aggregates shall be used for the backfill of the top of trenches below paved areas. Except where otherwise specified, that aggregate have the following gradation:

Gradation of backfill on top of trenches below paved areas							
Sieve size (mm):	37.5	25	19	4.75	2.0	0.425	0.075
Per cent passing by weight:	100	60-100	55-85	35-60	25-50	15-30	8-15

7.1.3.3 Drainage Fill and Filter Materials

Free drainage fill and filter material shall be formed of hard durable grain and shall be free from clay, silt, soluble or organic matter. The particle size distribution shall be in accordance to the filter rules.

The Contractor shall provide for free drainage materials from approved sources. The Contractor may use material from excavation, provided it is suitable and processed in compliance with the specification of free drainage material.

7.1.3.4 Rip Rap

Riprap material shall be sound, un-weathered and with low water absorption capacity in order to avoid cracking, bursting and dripping as a result of weather influences.

The rock shall mainly consist of large pieces with lateral lengths from 150 to 400 mm and smaller parts to secure the boulders against sliding and to provide stability to the fill structure.

The density of riprap material shall be not less than 2.2 t/m³ (solid volume without voids) and each piece of riprap shall have is greatest dimension not large than twice its least dimension.

The dimension of the riprap material should be 250x250x250 mm for 90 percent of the material.

The material delivered shall be dumped and graded off to a uniform surface up the lines and grades shown on approved drawings. No pockets of rocks and clusters of large blocks shall be permitted.

The Contractor shall submit full details of the proposed source, certified test results and samples for the approval of the Engineer.

7.1.3.5 Stone Pitching

The material used in stone pitching shall be obtained by the Contractor from sources approved by the Engineer.

The stone shall be sound, durable and hard. It shall be free from laminations, weak cleavages and undesirable weathering and shall be of such properties that it shall not disintegrate from the action of air, water or in handling and placing.

The dimensions of stones shall range between 200 and 400 mm. The minimum plain dimensions shall be of less than two thirds of the maximum plane dimension for each stone. The density of stones shall be not less than 2.2 t/m³ (solid volume without voids).

The stones shall be roughly dressed so that they fit reasonably close together. They shall be laid to a true and even surface, the spaces between the stones being clinked with spalls.

7.1.3.6 Reuse of Excavated Material

Where, in the opinion of the Engineer, excavated materials are not suitable for refill without resorting to sieving or other special means, the Engineer may instruct the Contractor:

- To sieve out stones as may be necessary to meet graduation requirements
- To transport suitable materials from trench excavation at distances exceeding 200m from the section to be backfilled (overhaul) or
- To import material from suitable, borrow pits to the section to be backfilled.

7.1.3.7 General Backfill

Backfilling materials and methods are generally subject to the approval of the Engineer. The approved materials shall be placed in layers, not exceeding 200 mm in depth before compaction and shall be well compacted as specified in the following:

The layers of fill material shall be placed in such a manner as to maintain adequate drainage and to prevent accumulation of water.
The timing and rate of placing of fill material around or upon any completed or partially completed structure shall be arranged in such a way that no part of the works is overstressed, weakened, damaged or otherwise endangered.

Around structures the material shall be placed as to exert a uniform pressure and each layer shall be placed with a fall to prevent the accumulation of water.
Where necessary, the moisture content of the backfill has to be adjusted to an optimum either by drying out or by adding water. After such treatment the backfill shall be thoroughly mixed until the moisture content is uniform.

Placing the backfilling, due allowance for any settlement that may occur before the end of period of maintenance shall be made. Where necessary, the Contractor shall at the end of the period of maintenance remove any excess material or make up any deficiency of backfilling to specified levels.

The Contractor shall, when placing the backfilling, make due allowance for any settlement that may occur before the end of the Defects Liability Period. Where necessary, the Contractor shall at the end of that period remove any excess material or make up any deficiency of backfilling to specified and required levels.

7.1.3.8 Backfill Adjacent to Completed Structures

The Contractor shall start backfill only after the walls, floors and slabs have been completed and have attained their full strength. Backfill around the walls of tanks and reservoirs shall not commence before successful completion and testing and after having the Engineer's approval.

The layers of backfill material shall be placed in such a manner as to maintain adequate drainage and to prevent accumulation of water. The material shall be placed with particular care for insulation and watertight paints and all other protective or conserving surfaces and as to exert a uniform pressure around the walls of a structure and each layer shall be placed with a fall to prevent the accumulation of water.

Special attention shall be paid to the compaction of material laid immediately adjacent to concrete walls as to ensure that the material is well compacted. Hand operated vibrating plate compactors; vibro-tampers or power rammers shall be used. The compacting shall be carried out in such a way as to avoid in any case direct contact of the compacting machinery and the building.

In other cases, vibrating compactors or pneumatic tyre rollers of types approved by the Engineer may be used for compaction.

7.1.3.9 Embedding of Pipes

Embedding of pipes shall be carried out in accordance with EN 1610.

7.1.3.9.1 Ductile Iron and PVC pipes

shall be laid on a 150 mm compacted bed of sand or approved excavated material and shall be embedded by sand or approved excavated material to a level of 300 mm above the top of the pipes. Embedding material shall be placed by hand and compacted in layers of not more than 100 mm compacted thickness. The material shall be compacted to at least 90 % maximum density below and around the pipes as to provide firm and continuous support.

The Contractor shall ensure that the pipe is not displaced or damaged by the embedding operation.

7.1.3.9.2 PE pipes for house / service connections

shall be laid on a 100 mm compacted bed of sand or approved excavated material and embedded by hand up to 150 mm above the top of the pipes, using the methods described above.

7.1.3.9.3 Concrete Pipes

Except where concrete or granular bed is specified, the bedding material for concrete sewers shall consist of crushed stones or gravel, be free from stones and lumps and be graded 0/25 mm.

The pipe bed shall be backfilled by hand from 150 mm below the bottom of the pipes to a level of 300 mm above the top of the pipe and compacted to at least 90% maximum modified proctor density.

7.1.3.9.4 Approval of Embedding

The Contractor shall take all precautions to fix the pipes in their location. This includes the bedding of pipes and partial refilling of trenches leaving the joints exposed while awaiting pressure tests.

Formal approval of embedding shall be obtained from the Engineer prior to the testing of pipes.

7.1.3.10 Main Backfill of Trenches

Backfilling of trenches shall be carried out in accordance with EN 1610.

From the top of the bedding layer up to the finished ground level, the trench shall be backfilled with approved selected material, compacted by mechanical methods approved by the Engineer in layers with a thickness of not more than 150 mm.

Each layer shall be compacted separately. Compaction shall be not less than 95% modified proctor density. Where necessary, the Contractor shall adjust the moisture content of the refill material to assist the compaction either by drying out or by sprinkling with water.

The Contractor shall provide adequate number of power tampers or other compaction equipment subject to the approval of the Engineer and sufficient water on site for moistening

The Contractor shall, when placing the backfill, make due allowance for any settlement that may occur before the end of Defects Liability Period. Where necessary, the Contractor shall at the end of this period remove any excess material or make up any deficiency of backfilling to specified levels.

In the event that excavated material is insufficient or unsuitable for backfilling, the Contractor shall use imported fill material from approved borrow pits.

Where directed by the Engineer, trench excavations shall be backfilled with concrete, class C 8/10. Likewise, the Contractor shall use cement stabilised backfill where shown on the drawing or as directed by the Engineer.

7.1.3.11 Disposal of Surplus Material

The disposal of surplus backfill material shall be deemed to be included in the rates for the respective backfilling operations.

The Contractor shall make his own arrangements to dispose off all surplus backfill and unsuitable excavated material from any part of the Work. The material shall become the property of the Contractor and shall be disposed Off-Site under his sole responsibility.

The Contractor shall clean the Site and the surrounding ground immediately after completion of works and leave the construction sites clean and tidy to the satisfaction of the Engineer.

7.1.4 Backfilling Sundries

7.1.4.1 Backfilling under Paved Areas

When excavation is made in highways, roads, sidewalks or any other paved area, the trench shall be backfilled and thoroughly compacted up to the bottom of the sub base of the surrounding pavement.

The remaining top of the trench shall be filled with graded and well compacted aggregate up to the top of the base of the pavement.

The further reinstatement of surfaces shall comply with the existing pavements.

7.1.4.2 Backfilling around Manholes

Backfilling around manholes and material used for it shall meet the specifications set out for the backfilling of adjacent trenches.

In roads with a width over 3 m, the material around manholes shall be selected and compacted to meet the requirements of base and sub base.

7.1.4.3 Backfilling in Agricultural Land

If pipe alignments cross agricultural land, the trench shall be backfilled to the top of adjacent land; whereby the top 30-cm of the trench shall be filled with the agricultural top soil originally found before excavation.

7.1.4.4 Backfilling in Watercourses

In riverbeds the pipes shall be fully encased with reinforced concrete and the top of the excavation shall be covered with gabions, laid by hand and extending 1m on either side of the excavated trench; likewise, in ditches clad with masonry, the masonry shall be reinstated after completion of backfill with concrete and in small ditched without any surface cladding the trench shall be backfilled to the invert of the ditch with concrete. Concrete shall be reinforced with 80kg/m3 steel. Concrete shall be of class C20/25.

7.1.4.5 Field Drains

Should any existing subsoil or field drains be uncovered during general excavation, the Contractor shall either carefully replace them when backfilling, or, if this is impracticable, shall divert them to new drains or ditches, or otherwise relay them as the Engineer may direct.

7.1.5 Embankments

7.1.5.1 Embankments in General

The term "embankment" includes the construction of embankments around structures, hard or other backfill, embankments for road works and the like.

Backfilling to general excavations, the forming of soil tips and the re-filling of trenches are specified and included in the clauses dealing with backfill.

7.1.5.2 Materials for Embankments

Excavated material (including material from borrow pits) to be used as fill material for embankments shall be free from clods and lumps and shall be approved by the Engineer.

If not otherwise directed, cohesive soil shall be placed in layers not exceeding 200 mm in compacted thickness; cohesionless soil shall be placed in layers not exceeding 300 mm in compacted thickness.

Material for hard filling shall be as specified below.

Should the material being placed as filling, while acceptable at the time of selection, become unacceptable to the Engineer due to exposure to weather conditions or due to flooding or become puddled soft or segregated during the progress of the works, the Contractor shall at his own expense remove such damaged, softened or segregated material and replace it with fresh approved material.

7.1.5.3 Filling with Hardcore

All fill under structures, unless indicated otherwise on approved drawings or instructed by the Engineer, shall be constructed with hardcore obtained from sources approved by the Engineer.

Hardcore shall be hard inert material passing a 75 mm sieve and be free from clay, silt, soil and vegetable matter and shall not deteriorate in the presence of water.

Hardcore shall be placed in layers not exceeding 150 mm thickness after consolidation and each layer shall be compacted by mechanical means. The final surface of hardcore shall be blinded with fine crushed stone and thoroughly compacted.

7.1.6 Reinstatement and Maintenance

7.1.6.1 Reinstatement of Paved Surfaces

The Contractor shall restore all pavements or other surface structures removed or disturbed as a part of the work to a condition suitable and satisfactory to the Engineer.

No pavement shall be restored unless and until, in the opinion of the Engineer, the condition for backfill is given in such a way as to properly support the pavement.

The reinstatement of road surfaces and other pavements shall be commenced upon approval of the Engineer of the completed backfill and shall be done, if not otherwise stated, as follows:

The top of the pipe trench (below the top of the base) shall be filled with graded aggregate (0 – 60 mm of natural stabilized material), watered, placed in layers of max.15 cm thickness and compacted to not less than 95% of maximum dry density according to modified proctor test.

At pipeline crossings, the top 30 cm of the trench shall be filled with plane concrete C12 / 15.

At the top of the base, the width of the trench shall be increased for 15 cm on each side. In order to ensure appropriate adjustment of the surfaces the Contractor shall use such methods as shall ensure the breaking of the pavement along straight lines, preferably by cutting. The face of the remaining pavement shall be approximately vertical.

The surface shall be restored in accordance with the existing pavement and/or the direction of the Engineer.

7.1.6.2 Reinstatement of Unpaved Surfaces

Gravel roads and unpaved roads shall be reinstated to their original condition. If the original road construction cannot clearly be applied, then 100 mm approved large gravel and 150 mm well-graded gravel compacted to 95% of maximum density shall be provided.

7.1.6.3 Surface Reinstatement in Agricultural Fields

After the Contractor has completely backfilled the trenches in fields and grass verges to the level specified, he shall replace all topsoil previously removed and it shall be evenly distributed and levelled over the full extent of the stripped area.
Such working area occupied by the Contractor as was originally grown with grass shall be sown with grass seed of equivalent quality and maintained until the new grass is properly established.

Other areas not originally down to grass shall be dressed with suitable fertilisers harrowed in so as to restore the original level of fertility.

7.1.6.4 Reinstatement of Existing Services

Where excavation is carried out close to or across the line of sewers, pipes, cables or other services, whether underground or overhead, the Contractor shall, where necessary, provide at his own cost temporary supports or slings and where such services are temporarily disturbed, they shall be replaced.

7.1.6.5 Reinstatement of Hedges, Fences and Walls

Where excavation disturbs features such as hedges, fences and walls, the Contractor shall, as a temporary measure, provide temporary fencing for any such parts of such barriers.

After excavation has been reinstated, the Contractor shall carry out such work as approved by the Engineer for permanent restoration of such barriers.

In case of hedges, saplings of the appropriate species and on both sides shall replace the section removed by providing an adequate post and barbed wire fence.

During the period of maintenance all hedges replanted in the above manner shall be inspected and any dead sapling replaced by the Contractor.

The reinstatement of the backfilled surface shall be done at the Contractor's own expense and include (1) the re-excavation of the top surface, base and sub base, (2) compacting the backfill in the trench, (3) backfilling the base and sub base with graded aggregate and (4) reinstatement of the surface according to surface conditions met before.

7.1.7 Auxiliary Works

Unless otherwise specified, all and any kind of works, materials, services, safety measures, etc., as well as, and if so requested by the Engineer, all tests and samples required for the Completion of the Works shall be included in items and prices figuring in the Bill of Specifications and in the Bill of Quantities. Hence, the auxiliary works comprise, but are not necessarily limited to, the following:

Removing and storing of boundary stones, bench marks, etc., protection of surveying points and designation by means of boards, survey and protection of all secondary survey points, profiles, etc.;

Difficulties to be overcome where excavation may have to be carried out in layers of by hand;

Keeping off or diversion of water, any pumping, required, difficult work caused by water, etc.;

Removal of any groins, buried pipes, wattle work, fascines and the like that might interfere with excavation profiles, irrespective of whether or not such structures are specified in the Bill of Quantities;

Difficulties resulting from the specifications relating to fills, compaction tests, eliminating unsuitable material from fills, and, if necessary, mixing of different soil materials;

Transport of excavated material to fill or deposit, placing and spreading in layers according to conditions and drawings, and careful compaction;

Difficulties in transport due to existing subsoil conditions;

Grading of intermediate and top fill surfaces and slopes to lines and levels required;

Sorting of excavated material which, if necessary, is to be used for special purposes;

Any expenditure for providing, maintaining and later removal of drive ways and roads, providing, placing, maintaining and later removal of conveying and dumping equipment that might be required.

7.1.8 Top Soil

So far as practicable, topsoil shall be obtained from material emanating from excavations and separately stored in temporary spoil tips as specified or directed by the Engineer.

If, in the opinion of the Engineer, the Contractor can not reasonably obtain sufficient topsoil in this way, the Engineer may order the Contractor to provide extra material from an approved source off the Site.

Topsoil shall be evenly spread and trimmed over embankments and filled excavation to the slopes and levels as shown on approved drawings. The depth after spreading and trimming shall be 250 mm measured perpendicular to the surface. All clods and lumps shall be broken up and any rubbish, large stones, roots and weeds shall be removed.

Where the upper layer of natural soil is poor in organic matter, it shall be improved to a minimum depth of 25 cm by adding either clay or sand or silt to create a loamy soil texture consisting of 40% sand (size > 0.05 mm), 30% silt (size 0.05-0.002 mm) and 30% clay (size < 0.002 mm).

A shallow ripping shall be required before adding clay or sand or silt which shall be mixed properly by using a disk harrow. If it shall be necessary for topographical reasons, levelling shall be carried out before mixing clay, sand or silt.

7.1.9 Grassing

Where the topsoil shall be sown with grass seed, the top 75 mm of the previously laid topsoil shall be brought to a fine tilt suitable for seeding, and sowing shall be carried out as soon as practicable after completion of top soiling having due regard to the season and the weather conditions. If ordered by the Engineer, subsoil lime and fertiliser shall be applied in accordance with his directions.

After the seed has been sown uniformly, they shall be raked and lightly rolled into the surface. The young grass shall be kept free from weeds and any bare patches shall be re-seeded until an even close turf is established. The grass shall be watered, mown and rolled as required and maintained in good condition until the expiry of the period of maintenance.

The Contractor shall replace, at his own cost, any damaged area where the grass has dried up or has not adhered to the slope surface, which contains undesirable plants or which has an irregular or unattractive appearance in the Engineer’s opinion.

7.1.10 Shrubs and Trees

Shrubs for borders and hedges shall have a minimum height of 0.6 m. Aluminium of 2 plants per m² are to be planted to create an evenly dense area.

Trees to be supplied and planted shall have a minimum height of 1.5 m.
For the plant holes vegetable soil is to be used. Stabilization of freshly planted trees against wind actions shall be provided. Shrubs and trees shall be suitable for the climatic conditions on Site.
The Engineer shall approve the species the Contractor intends to plant.

Growth of shrubs and trees shall be guaranteed for one year from the day of planting. Any shrubs and trees, which have died within the guaranteed period, must be substituted without extra payment.

7.1.11 Dressing of Topsoil

After planting of lawn, shrubs or trees, the topsoil shall receive a dressing of fertiliser. As minimum requirements, dressing of topsoil shall be done with lime, potash and super-phosphate, as applicable.

Dressing of topsoil shall only be carried out after watering and raining. The surface of the soil shall be kept wet until fertilisers have dissolved.

7.2 Laying of Mains and Installation of Pipework

7.2.1 Pipe Laying for Mains

7.2.1.1 Routing of Mains

Before setting out any section of a main, the Contractor or his representative shall make an inspection on Site together with the Engineer. The Contract Drawings show the approximate lines and levels to which the main is to be built however such alignments are subject to the amendments made by the Engineer on Site. He may vary or abandon any part or parts of the route of mains indicated on Drawings and issue the respective instructions to the Contractor.

The Contractor shall prepare the working drawings and shall lay the pipes in accordance with any such variation the Engineer may issue.

7.2.1.2 General Requirements for Pipe Laying

All pipes and specials shall be laid in accordance with the alignment, levels and gradients shown on the working drawings approved by the Engineer, adjusted in the field by the Contractor as may be required from time to time and as finally authorised by the Engineer. The completed main shall run straight between the bends or any curved alignment and a uniform gradient shall be accurately maintained between changes of gradient as shown on Drawings or otherwise instructed by the Engineer.

The bottom of the trenches shall be graded and prepared to provide a firm and uniform bearing throughout the entire length of each pipe; bell holes shall be provided as required.

The Contractor shall inform the Engineer sufficiently in advance when a section of trench has been prepared ready for inspection. No pipe shall be laid until the trench bottom has been inspected and approved by the Engineer.

Before being positioned, each pipe shall be thoroughly examined to ensure that it is free from defects and shall have all dirt removed from the inside thereof. The Contractor shall lay the pipe in accordance with professional practice and install all fittings, specials and adaptors as may be required for the proper execution of the works.

The Contractor at his own expense shall repair any injury of the protective coating of the pipes from any causes during the construction of the pipeline to the satisfaction of the Engineer.

At the end of each day’s work a strong wooden plug or iron disk shall be firmly fixed in each open end in order to prevent any foreign material to enter the laid pipe.

7.2.1.3 Cutting of Pipes

The Contractor shall cut pipes exclusively with the cutting tools recommended by the manufacturer for the particular pipe material and approved by the Engineer. Cuts shall be smooth and perpendicular to the axis of the pipe. Damages to coatings or linings (if any) shall be repaired. Spigot ends to be joined to sockets shall be chamfered.

7.2.1.4 Matching Pieces

Matching pieces required in any section of a main or to terminate the main in manholes or other parts of the works shall be cut only after all adjacent pipes have been installed and jointed.

7.2.1.5 Laying of Ductile Iron Pipes

7.2.1.5.1 Installation

The pipes shall be positioned and bedded in the trenches on the compacted and finished bedding and jointed in an approved manner.

After placing a length of a pipe in the trench, the spigot shall be centred in the socket of the corresponding pipe using the proper lubricant, rubber rings and methods in strict accordance with the manufacturers' instructions and the pipe shall be forced home by rack and lever and brought to the correct line and grade. Particular care shall be applied to ensure that the spigot end of the pipe does not damage or displace the rubber ring joint. The pipe shall be secured in place with approved backfill material tampered around it, except at the socket.

The Contractor shall supply all the materials, equipment and tools required for the proper jointing of the pipes at his own cost.

All joints shall remain uncovered until successful completion of the pressure test.

7.2.1.5.2 Thrust Blocks

Bends, tees, tapers, plugs, caps, valves etc. shall be well braced against undisturbed soil at the edge or the end of the trench with concrete thrust blocks or collars (end caps), except for in case of restrained joints of the pipes and fittings.

The blocks shall be placed so that the joints shall remain accessible for repair.

Where it is not possible to brace against undisturbed soil, suitable fetters shall be arranged as directed by the Engineer.

Thrust forces and shaping of the thrust blocks and collars shall conform to the field test pressure (STP) and be calculated by the Contractor for each individual thrust block considering the actual soil bearing capacity. Where large abutments are required, the bearing plate and the transmitting prism shall be of reinforced concrete B20/25. The dimensions, classes of concrete and steel reinforcement given in standard drawings are approximate only.

Alike for thrust blocks, the Contractor shall determine the structural requirements and design manholes to safely transmit the thrust into the natural soil.

Concrete thrust blocks and collars shall be allowed to cure for at least 7 days before backfilling or bringing thrust to the blocks.

7.2.1.5.3 Restrained joints

The Contractor shall lay sections with restrained joints strictly according to the manufacturer's instructions. Lengths of anchoring tails shall be computed by the Contractor acc. to the field test pressure (STP) for each individual bend or tee considering the actual soil parameters. Adjacent to the respective bend, upper bedding and side fill shall be of concrete B8/10 acc. to Standard drawing. Anchoring tails shall be completely backfilled prior to the pressure test.

7.2.1.6 Laying of PVC-U Pipes

The same applies as for ductile iron pipes, subject to the following:

7.2.1.6.1 Marker Tape

A marker tape shall be laid 300 mm above pipe crest for easy location of the pipe route. The tape shall be blue in colour and of 200 mm overall width and contain an aluminium strip throughout its length and shall have warning signs "Caution Water Main below" along the top section of the pipe. Samples of the tape shall be submitted to the Engineer for his approval.

7.2.1.7 Laying of Steel Pipes

If ordered steel pipes shall be used as directed by the Engineer, the procurement, laying and measurement of steel pipes shall be in accordance with the rules outlined for DI pipes.

However, the specific requirements for the jointing and handling of black steel pipes are summarised as follows:

Steel pipes shall be joint together by electric butt-welding. Welding shall be in accordance to approved standards and Manufacturer's prescriptions. The electrodes used shall be suitable for overhead welding and shall be subject to the Engineer's approval. Pipes shall be joined beside the trench.

The Contractor's welders shall have passed welding tests as prescribed by the Engineer and no welder shall work on the pipes before passing the test and being approved by the Engineer in writing.

After passing the prescribed pressure test, external coating of all joints shall be completed in accordance with the Engineer's instructions and to his satisfaction.

After inspection of the joints, the pipes shall be lowered into the trench. Steel pipes shall be joint together by electric butt-welding. Welding shall be in accordance to approved standards and Manufacturer's prescriptions. The electrodes used shall be suitable for overhead welding and shall be subject to the Engineer's approval. Pipes shall be joined beside the trench.

The Contractor's welders shall have passed welding tests as prescribed by the Engineer and no welder shall work on the pipes before passing the test and being approved by the Engineer in writing.

After passing the prescribed pressure test, external coating of all joints shall be completed in accordance with the Engineer's instructions and to his satisfaction.

After inspection of the joints, the pipes shall be lowered into the trench.

7.2.1.8 Laying of PE Pipes

7.2.1.8.1 Installation

The pipes shall be taken from the roll, straightened, cut to the required lengths, positioned and bedded in the trenches on the compacted and finished bedding and jointed with the appropriate fittings.

7.2.1.8.2 Marker Tape

At a distance of 300 mm over the service pipe a ferrous tracking tape shall be laid for easy location of the pipe route. The tape shall be blue in colour and of 200 mm overall width and contain an aluminium strip throughout its length and shall have warning signs "Caution Water Main below" along the top section of the pipe. Samples of the tape shall be submitted to the Engineer for his approval.

7.2.1.9 Laying of Galvanised Iron Pipes

If ordered by the Engineer, the installation of GI pipes, diameters ranging from ½" to 1", from behind the water meter to the consumer's house piping system shall be executed by the Contractor.

Piping shall include all fittings, connecting materials, supports, earthwork chiselling, mending and pressure tests for the complete installation of GI pipes in every respect.

Payment shall be according to linear meters of pipes laid from behind the water meter to consumer's house connection point.

7.2.1.10 Marker Posts

Markers for pipelines, valves and hydrants shall be prefabricated of concrete C 20/25 with the following dimensions: 15/15/250/ cm, with chamfered edges and placed in a concrete bed of 50/50/50 cm so that the marker protrudes 200 cm from ground level. The posts shall bear head of 25x35cm having a recess of 10mm and the size of 20x20cm to receive the plate. At the edges of the recess, 4 dowel holes shall be provided.

Figures and letters on the plate shall show the following information on the valves: number of valves, DN and offsets; for hydrants: number of hydrant and offsets. Figures and letters shall be placed by the Contractor.

7.2.2 Reinforced Concrete Chambers

Reinforced concrete chambers shall be located as indicated on Drawings or directed by the Engineer. In-situ concrete chambers shall comply with the applicable specified requirements for Earth Works and Concrete Works.

Reinforced concrete chambers shall be quoted for, without the various pipeline appurtenances as valves, meters, dismantling joints etc. These items shall be paid separately as extra over for pipeline installations.

All external pipework before entering and after exiting a reinforced concrete chamber shall be fitted with flexible joints at a minimum distance of 300 mm from the external face of the chamber.

The following types of chambers shall be applicable:

Air valve chamber
Washout chamber
Water meter chamber in main lines

The structures shall be built into the pipelines in accordance with Standard Drawings. Given dimensions on the drawings shall be verified by the Contractor so as to suit the pipe installation and the prevailing condition on Site.

Cast iron covers with frames shall be installed for all valve chambers as specified or shown on drawings. The wording on each cover shall be agreed with and approved by the Engineer prior to ordering. Covers to be used in surfaces, which are subject to vehicular traffic, shall be Class D, according to EN 124.

Two pairs of keys for use with each type of cover shall be handed over by the Contractor after completion of works at no extra cost.

All valve chambers shall be equipped with step irons as indicated in drawings or as directed by the Engineer. Step irons shall be malleable cast iron according to DIN 1211, galvanised iron or as directed by the Engineer.

All valve chambers shall have pump sumps installed as shown on the Standard drawings or as instructed by the Engineer.

7.2.3 Pipework in Chambers and Pumping Stations

7.2.3.1 Erection of Pipework

7.2.3.1.1 Preparation of Pipes

The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly cleaned before and during erection and before it is placed into commission.

Cleaning shall include the removal of all dirt, rust, scale and welding slag due to site welding. All small-bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment.

7.2.3.1.2 Installation of Pipes

Care shall be taken during the erection of pipework to ensure that no loads of any kind are transmitted through to the pump flanges or the flanges of any other equipment. Care shall also be taken that pipe flanges are accurately aligned to prevent distortion of flanges and/or pipework when bolting together. Bolts of flanged connections shall be tightened uniformly, so that the gasket pressure is evenly distributed around the circumference.

7.2.3.1.3 Support of Pipework and Valves

All necessary supports including structural steel work foundations, hangers, saddles, sliding, expansion pieces, fixing bolts, foundation bolts, fixing and anchor points and all attachments shall be supplied to support the pipework and its associated equipment in an appropriate manner.

Valves, meters, strainers and other devices mounted in the pipework and its associated equipment shall be supported independently of the pipe to which they connect.

7.2.3.1.4 Supports and Passage of Pipes through Walls

Whenever pipework passes through walls, the Contractor shall provide block outs and install the pipes only after the structure has been completed and grout the pipes in secondary concrete after the pipes have been accurately positioned. Where axial thrust is to be transmitted, puddle flanges shall be grouted and reinforcement be placed in such manner that the thrusts shall be safely transmitted into the structure.

In exceptional cases the Engineer may accept to incorporate the pipes into primary concrete provided that all pipe elements and appurtenances are completely wrapped into PE-sheets.

7.2.4 Disinfection of Mains

Disinfection of mains shall be carried out in accordance with EN 805.

EN 805 recommends several disinfectants. The disinfectant may be selected by the Contractor and submitted to the Engineer for approval together with the method of application. It is recommended to use a hypochlorite solution; the process for the hypochlorite solution is given hereinafter.

After a section of the mains has been hydraulically tested successfully and before being commissioned, the Contractor shall proceed with the disinfection.

Firstly, the mains section shall be flushed with clean water to remove foreign matter.

Then the mains section shall be disinfected with a chlorine solution at a rate as to obtain 50 mg/l of active chlorine at the point of introduction. The line shall be blown-off until a residual of 5 mg/l chlorine is obtained at the point of blow-off.

If a residual of 5 mg/l chlorine is obtained, the blow-off shall be closed and the water allowed to remain in the pipe for a minimum of 24 hours (static method). After this period the water shall be tested for residual chlorine at the point of blow-off. If no residual chlorine remains, the process shall be repeated until satisfactory results are obtained.

After completion of the disinfection process the main shall be flushed with 0.5 mg/l chlorinated water until effluent concentration at the point of blow-off is less than 0.5 mg/l.

Any effluent from the disinfectant shall be duly neutralised.

7.3 Concrete Works

7.3.1 General

7.3.1.1 Scope

Concrete Works as specified hereunder shall include the supply of materials, mixing of concrete, formwork, reinforcement, placing, compaction and curing of concrete and site clearance after completion of Works.

The bid prices entered in the Bill of Quantities shall fully include the value of works described under the several items and shall cover the cost of all labour, subsidence, travelling, materials, admixtures, temporary works, yards and stockpiles, sampling and testing and any other expenses whatsoever together with all risks, liabilities and obligations set forth or implied in the Contract Documents.

7.3.1.2 Standards and Rules

The Contractor shall carry out the works described in this Section in accordance with the appropriate EN standards or equivalent international standards.

The main standards are, but shall not be limited by the following:

DIN 59	Concrete mixer
DIN 488	Reinforcing steel
DIN 1045	Concrete, reinforced and pre-stressed concrete structures
DIN 1048	Test methods for concrete; fresh concrete
DIN 1164	Cement
DIN 4030	Evaluation of liquids, soils and gases aggressive to concrete
DIN 4226	Aggregates for concrete and mortar
DIN 4227	Pre-stressed concrete
DIN 4235	Compacting concrete by vibrating
DIN 18203	Tolerances in building construction

7.3.1.3 Classes of Concrete

The classes of Concrete to be used in the works have the following strength:

C8/10	strength, 28 days after mixing:	fck cyl =8N/mm² / fck cube = 10N/mm²
C12/15	strength, 28 days after mixing:	fck cyl =12N/mm² / fck cube = 15N/mm²
C20/25	strength, 28 days after mixing:	fck cyl =20N/mm² / fck cube = 25N/mm²
C30/37	strength, 28 days after mixing:	fck cyl =30N/mm² / fck cube = 37N/mm²

Unless otherwise agreed, the compressive strength shall be determined using cylinders □ 150 mm / 300 mm or 150 mm cubes (all concrete samples stored under water).

The different classes of concrete shall be used as follows:

- Class C8/10: for plain concrete only for fill in trenches, for blinding and for screed
- Class C12/15: for plain and reinforced concrete for screed and encasements

- Class C20/25: for reinforced concrete in civil structures, thrust blocks, manholes.
- Class C30/37: for watertight concrete in tanks, channels and where especially directed by the Engineer.

Cement used in the works for structural parts in the underground or in contact with wastewater shall be sulphate-resisting Portland cement.

7.3.1.4 Organisation of Concrete Production

At the commencement of the Contract, the Contractor shall submit for approval of the Engineer a method statement detailing his proposal for the organisation of concreting activities at the Site. The concrete production plant shall preferably be placed at the Site.

The method statement shall include:

- Plant proposed and layout of the production facility;
- Proposed method of organisation of the production facility
- Quality control procedures for concrete and concrete production;
- Method of transport including heat protection and placing of concrete;
- Striking times for formwork and procedure for temporary support of beams and slabs;
- Curing of concrete and ways to assure an optimum curing.

7.3.1.5 Aggregate Samples

Before work on trial mixes is commenced, the Contractor shall submit for approval 50 kg samples of each aggregate which he proposes to use.

The source of each aggregate shall be clearly marked on the container of each sample.

At the same time certified test results demonstrating compliance with relevant quality standards shall be submitted.

Samples approved by the Engineer's shall be preserved at Site for reference.

7.3.1.6 Record of Concreting

The Contractor shall keep accurate and up to date records of concreting showing for each day when sections of the works were concreted:

Date, time, weather and temperature;
Results of all concrete tests including identification for which parts of works the sampled material are representative;
Number of batches produced, weight and kind of cement used, volume of concrete placed, number of batches wasted or rejected;
Class of concrete, volume of concrete placed and number of batches used for each location.

The laboratory where concrete test have to be carried out shall be approved by the Engineer and the Employer and be accessible for the said parties at any time. The laboratory shall preferably be placed at the Site.

7.3.1.7 Concrete Mixes

At the commencement of the works the Contractor shall design a mix for each class of concrete which shall be required for use in the works and shall submit full details of the mix designs to the Engineer for approval. Each mix design shall be according to the requirements of the respective specification.

7.3.1.8 Construction Joints and Lifts

The Contractor shall submit to the Engineer, not later than 3 weeks before the commencement of concreting, drawings showing his proposals for placing concrete and the position of all construction joints which have to be located as not to impair the strength of the structure.

No concreting shall start until the Engineer has approved concrete placing and the position and form of construction joints.

Rebates, keys or notches shall be formed and water stops inserted as the Engineer may require.

The position of construction joints and the size of formwork panels shall be so coordinated that where possible the line of any construction joint coincides with the line of a formwork joint and that in any case all construction joint lines and formwork joint lines appear as a regular and uniform series.

For all exposed horizontal joints and purposely-inclined joints, a uniform joint shall be formed with a batten of approved dimensions to give a straight and neat joint line.

7.3.2 Materials

7.3.2.1 Cement

All cement used on the Work shall be standard brand Portland cement from a single approved source conforming to the requirements of Portland cement class CEM I 32.5 R or class CEM I 32.5 HS in accordance to DIN 1164.

Cement used in the works for structural parts underground or in contact with wastewater shall be sulphate-resisting Portland cement, class CEM I 32.5 HS.

The source of cement shall not be changed without prior approval of the Engineer.

Cement has to be delivered to the Site of works in the original sealed and branded bags. No cement shall be used which has been manufactured 6 months prior to its proposed use on Site or which has been in storage for more than 3 months.

The Contractor shall provide from each consignment of cement delivered to the Site such samples as the Engineer may require for testing.

Any cement which contains, in the opinion of the Engineer, air set or hardened lumps, re-powdered air-set material, foreign matter of contamination or what is unsatisfactory for any reason whatsoever shall be rejected and the Contractor shall promptly remove any such cement from the Site.

Cement, which has been stored on Site for more than 40 days, shall not be used in the works unless it is retested and it complies with the relevant standard.

7.3.2.2 Storage of Cement

Immediately upon arrival on Site, the cement shall be stored in silos or in dry, weather tight and properly ventilated structures with adequate provisions to prevent absorption of moisture.

All storage facilities shall be subject to the approval by the Engineer and shall be such as to permit easy access for inspection and identification.

Each consignment of cement shall be kept separately and the Contractor shall use the consignments in the order in which they are received.

7.3.2.3 Aggregates

Aggregates shall be hard, durable and clean and shall not contain deleterious material in such form or quantity as to adversely affect the strength of concrete. The aggregates shall be obtained from an approved source, shall be washed clean and shall conform to the requirements of DIN 1045 and DIN 1048.

The aggregates to be supplied shall not give rise to any alkaline reaction with the cement, weather silica or carbonate. In addition, the soluble chloride and sulphate content of the aggregates shall be such that the concrete mix as a whole complies with the specified limits of the salt content.

Tests for chlorides and for potential alkaline reaction shall be carried out when required by the Engineer at the Contractor's expense.

7.3.2.4 Storage of Aggregates

The Contractor shall provide storage facilities for aggregates, which have to be, made that:

Each normal size of course and fine aggregates shall be kept separate all the times;
Contamination of aggregates by the ground or other foreign matter shall be prevented effectively at all times
Each heap of aggregate shall be capable of draining freely
Aggregates are kept as cool as possible by shading and provision of water sprinkling if required.

The Contractor shall ensure that graded coarse aggregate is not segregated during tipping, storing and removal from storage.

Fine aggregate shall not be used unless, in the opinion of the Engineer, it is conditioned to acceptable and uniform moisture content. If necessary, to meet this requirement, the Contractor shall protect the heaps against weather and condition fine aggregate in accordance to requirements.

7.3.2.5 Water

Water for washing aggregates and for mixing of concrete shall be in accordance with DIN 1045 and DIN 4030 and shall be clean and free from objectionable quantities of organic matter, alkali, salts and other impurities.

If not otherwise directed or approved, the water for concrete mixing shall be drawn from the public supply at the Contractor's expense.

The water shall enter the mixer at the lowest possible temperature and shall not exceed 30°C.

During the execution of works the Contractor shall ensure that sufficient quantities of water for production and curing of concrete are available on Site at all times.

7.3.2.6 Admixtures

The use of admixtures is to be avoided whenever possible.

At the request of the Contractor or the Engineer, but in either case at the expense of the Contractor, an admixture may be added to the concrete in order to control the set, to effect water reduction and to increase workability.
Such admixture shall not contain calcium chloride and it shall be used in accordance to the manufacturer's instructions.

Admixtures shall not be used unless the Engineer has given his approval.

7.3.3 Concrete

7.3.3.1 Proportioning of Concrete Materials

Concrete shall be composed of cement, aggregates, water and, when unavoidable, of admixtures.
These materials shall be of the qualities specified and their proportioning shall be determined in accordance with all requirements imposed by DIN 1045 and be subject to the approval of the Engineer.

In general, the mix shall be designed to produce concrete capable to be placed so as to obtain maximum density and strength and smoothness to the surface.

The proportions shall be changed whenever necessary or desirable in the opinion of the Engineer.

7.3.3.2 Water-Cement Ratio and Compressive Strength

The minimum compressive strength and cement content shall be not less than required in the appropriate DIN Standard.

If necessary, to obtain the required strength, the Engineer may order the cement content of any class to be increased over the quantity specified in the standard. The Contractor at no additional cost to the Employer, if so ordered, shall furnish such increased quantities of cement.

The maximum water-cement ratio shall be less than 55 l of water per 100 kg of cement.

7.3.3.3 Limits of Salt Contents

All concrete mixes shall contain less than 0,6% total chlorides (as chloride ions) and less than 4.0% total acid soluble sulphate (as sulphite ions). Tests shall be carried out in accordance with the appropriate DIN Standard.

7.3.3.4 Consistency

The quantity of water added to a batch of concrete shall be in accordance with DIN 1045, just sufficient to produce a concrete which, in the judgment of the Engineer, can be placed properly without segregation and which can be compacted by vibration to give the desired density and smoothness of surface.

The quantity of water shall be changed as necessary, with variations in the nature or moisture content of the aggregates, to maintain uniform production of a desired consistency. The consistency of the concrete shall be determined in accordance with DIN 1048.

7.3.3.5 Mix Design

Samples of course and fine aggregates and cement proposed to be used in the work shall be tested. Test can be made at a laboratory accepted by the Engineer and by participation of him.

From analysis and test of samples furnished, the laboratory shall design a concrete mix to meet the requirements for each class of concrete required for use in the works.

The laboratory shall prepare 2 test cylinders of each design mix from the samples furnished and test them after 7 and 28 days, respectively.

Three copies of the test results shall be submitted to the Engineer for approval.

All cost for furnishing samples, mix design and testing shall be borne by the Contractor.

7.3.3.6 Trial Mixes

As soon as the mix designs are approved by the Engineer, 3 batches of concrete for each grade shall be made on site under full scale production conditions using the same means of the same plant the Contractor proposes to use in the works.

The portions of cement, aggregates and water shall be carefully determined by weight in accordance to the approved mix design and sieve analyses shall be made in accordance with DIN 4226 of fine and coarse aggregate used. In accordance with DIN 1048 three test cubes from each of the three batches shall be made by the Contractor in the presence of the Engineer from each trial mix.

The cylinders shall be made, cured, stored and tested with the method described in DIN 1048.

If the average value of the compressive strength of the nine cylinders taken from any trial mix is less than the target mean strength or any individual cylinder test result falls below 85% of the target mean strength, the Contractor shall redesign the mix and make a further trial mix.

7.3.3.7 Mixing of Concrete

All concrete prepared on site shall be mixed in accordance with DIN 1045 with batch mixers in accordance with DIN 459.

The mixing of each batch shall continue not less than 1,5 minutes after all materials including water are in the mixer.

Hardened concrete or mortar shall not be permitted to accumulate on the inner surfaces of the mixer. Re-tempering shall not be permitted.

7.3.3.8 Ready-mixed Concrete

Ready mixed concrete shall not be used in any part of the works without the written approval of the Engineer, which, when given, may be withdrawn at any time.

If ready-mixed concrete is accepted, the Contractor shall certify the Engineer that the ready-mixed concrete complies with the Specifications in all respects, and that the manufacturing and delivery resources of the proposed supplier as well as traffic conditions are adequate to ensure proper and timely completion of each concreting operation.

7.3.4 Reinforcement

7.3.4.1 Submissions and Approvals

The following submissions are required by this Specification:

Manufacturers test certificates for each delivery of reinforcing steel, showing the country of origin and tests

Manufacturer’s data on accessories;

All reinforcement drawings and bending schedules prepared by the Contractor.

Before concrete is placed against any formwork, the reinforcement shall be inspected by the Contractor and offered for inspection and approval by the Engineer.

In no case concreting shall be commenced prior to the inspection of the reinforcement by the Engineer and his written approval to proceed with concreting.

The approval procedure shall be preferably supported by a ‘pour-card’ system.

7.3.4.2 Steel Reinforcement

Steel reinforcement bars shall be hot rolled untreated bars conforming to the requirements of DIN 488. Only plain round bars BSt 220/340 GU (minimum yield strength 220 N/mm²; tensile strength 340 N/mm²) and BSt 420/500 S shall be used. Steel wire reinforcement shall be conform to the requirements of DIN 488 and shall be type BSt 500/550 M.

7.3.4.3 Accessories

The Contractor shall supply all accessories such as reinforcing steel supports, hold-downs, spreaders, hangers, tie wire and all other incidentals necessary to complete an acceptable installation of all concrete reinforcement.

All accessories shall be of steel with the exception of spacers to maintain concrete cover.

If not otherwise directed by the Engineer, the concrete spacers shall be in the form of a truncated cone or pyramid and shall be used with the larger face towards reinforcing steel.

7.3.4.4 Cutting and Bending of Reinforcement

Bars shall be cut and bent in accordance with the provisions of DIN 1045.

All bending shall be done cold with an approved bending machine.

Cut and bent bars shall be bundled and labelled for identification until they are incorporated into the work.

Re-bending or straightening of bars shall not be permitted.

7.3.4.5 Storage of Bars and Mesh

The Contractor shall stack separately and label the various type of reinforcement for identification.

Steel reinforcement shall be kept clean and free from pitting. Loose rust, mill scale, oil, grease, earth paint or any other material impairing the bond between the concrete and the reinforcement have to be removed thoroughly before fixing.

Reinforcing steel shall be stored under cover on wooden support, elevated from the ground surface.

7.3.4.6 Fixing of Reinforcement

All reinforcement shall be securely and accurately fixed in positions shown on the approved drawings using approved spacer blocks and chairs. The Contractor shall ensure that all reinforcement is maintained in position at all times, particular care being taken during placing of concrete.

Reinforcement in slabs shall be maintained in position by means of stirrups at 90-cm centres maximum. Reinforcement in walls with two layers of reinforcement shall be maintained in position by means of 6 mm U-or Z-shaped spacers at 180-cm centres maximum.
No part of the reinforcement shall be used to support formwork, assess ways, working platforms or the placing of equipment.

Welding of reinforcement is subject to the permission of the Engineer.

7.3.4.7 Concrete Cover

Except as otherwise shown in approved drawings, reinforcement shall be installed with clearance coverage as follows:

- All surfaces in contact with water or placed against soil: 5.0 cm
- Underside of slabs over water and beams and columns not exposed to soil or water: 4.0 cm
- Surfaces exposed to air and all interior surfaces in buildings: 3.0 cm

7.3.4.8 Tolerances

Tolerances in placing reinforcement shall be:

- For members 60 cm or less in depth: +/- 0.5 cm
- For members more than 60 cm in depth: +/- 1.5 cm

7.3.4.9 Approval by Engineer

In no case shall any reinforcing steel be covered by concrete until the number, correct diameter and position of the reinforcement have been checked by the Engineer and his permission given in writing to proceed with the concreting.

7.3.5 Formwork

7.3.5.1 Submissions

Design and shop drawings for formwork
Layout of panels

Before concrete is placed against any formwork, the formwork shall be inspected by the Contractor and offered for inspection and approval by the Engineer.

In no case concreting shall be commenced prior to the inspection of the framework by the Engineer and his written approval to proceed with concreting.

7.3.5.2 Requirements

Formwork shall be constructed of timber, sheet metal or other approved material.

The Contractor shall furnish all struts, braces and ties to withstand the placing and vibrating of concrete.

Except, when otherwise expressively approved by the Engineer, all material brought on the Site as forms, struts or braces shall be new material.

The class of finish at concrete is specified as follows: All visible surfaces shall be class A finish (see chapter 4.3.5.6) by the use of steel or plywood formworks.

For each class of finish the Contractor shall present sample panels to the satisfaction of the Engineer.

If the sample panels do not meet the requirements, in the opinion of the Engineer, the Contractor shall present new samples.

Sample panels shall not be less than 2 m² in area.

7.3.5.3 Form Ties

Form ties for use in water-retaining structures shall incorporate a diaphragm not less than 50 mm diameter welded to the midpoint of the tie, designed to prevent water passing along the tie.

Form ties with integral water stops shall be provided in a cork or other suitable means for forming a conical hole to ensure that the form tie may be broken off back of the face of the concrete.

The maximum diameter of removable cones for rod ties, or of other removable form tie fasteners having a circular cross section, shall not exceed 40 mm and all such fasteners shall be such as to leave holes of regular shape for reaming.

Holes left by the removal of fasteners having from the end of snap-ties or form ties shall be reamed with suitable toothed reamers so as to leave the surfaces of the holes clean and rough before being filled with a chemical mortar such as Sikadur 31 from SIKA or equivalent products.

Wire ties for holding forms shall not be permitted. No form-tying device or part thereof, other than metal, shall be left embedded in the concrete; not shall any tie be removed in such manner as to leave a hole extending through the interior of the concrete member.

The use of snap-ties, which cause spalling of the concrete upon form stripping or tie removal, shall not be permitted.

If steel panel forms are used, rubber grommets shall be provided where the ties pass through the form in order to prevent loss of cement paste.

Where metal rods extending through the concrete are used to support or to strengthen forms, the rods shall remain embedded and shall terminate not less than 50 mm back from the surface in the case of reinforced concrete and 150 mm in the case of un-reinforced concrete.

7.3.5.4 Number of Forms

A sufficient number of forms of each kind shall be provided to permit the required rate of progress to be maintained.

Whenever, in the opinion of the Engineer, additional forms are necessary to maintain the progress of works, such additional forms shall be provided by the Contractor at his own expense.

The design of concrete forms, false work and shoring shall comply with applicable standards.

7.3.5.5 Design of Formwork

The Contractor shall be responsible for the adequacy and safety of formwork and the compliance of the formwork with the Specification:

All forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete.

Concrete construction joints shall not be permitted at locations other than those shown on approved shop drawings. When a second lift is placed on hardened concrete, special precautions shall be taken in the location and tightening of ties at the top of the old lift and the bottom of the new to prevent any unsatisfactory affect whatsoever on the concrete.

All exposed arises and exterior corners shall be chamfered (20 x 20 mm), unless specifically shown otherwise in the drawings or directed by the Engineer.

All vertical surfaces of concrete members shall be formed, unless placement of the concrete against the ground is called for and explicitly authorised by the Engineer. Permission for placing concrete against trimmed ground in lieu of forms will be granted only for members of limited height and where the properties of the ground allow for it.

Top formwork shall be used on any inclined concrete surface steeper than 15° to the horizontal.
All forms shall be true in every respect to the required shape and size, shall conform to the established alignment and grade and shall be of sufficient strength and rigidity to maintain their position and shape under the loads and operations incident to placing and vibrating the concrete.

Concrete construction joints shall not be permitted at locations other than those shown on approved shop drawings. When a second lift is placed on hardened concrete, special precautions shall be taken in the location and tightening of ties at the top of the old lift and the bottom of the new to prevent any unsatisfactory affect whatsoever on the concrete.

All exposed arises and exterior corners shall be chamfered (20 x 20 mm), unless specifically shown otherwise in the drawings or directed by the Engineer.

All vertical surfaces of concrete members shall be formed, unless placement of the concrete against the ground is called for and explicitly authorised by the Engineer. Permission for placing concrete against trimmed ground in lieu of forms will be granted only for members of limited height and where the properties of the ground allow for it.

Top formwork shall be used on any inclined concrete surface steeper than 15° to the horizontal.

7.3.5.6 Formed Surfaces

Finishes to formed concrete surfaces are classified as follows:

Class A: Surfaces exposed to view where good appearance is of special importance. To achieve the required finish, the formwork shall be faced with plywood or equivalent material in large sheets. Wherever possible, joints shall be arranged to coincide with architectural features. All joints between panels shall be vertical and horizontal, unless otherwise directed. Unfazed wrought boarding or standard steel panels shall not be permitted for class A finish. Wooden surfaces shall have a sealed surface.

Class A formwork shall be used for the inside of water tanks for potable water.

Class B: Finish for surfaces, which are exposed to view but where the highest standard of finish is not required. Forms shall be faced with wrought boards with square edges arranged in a

uniform pattern or, alternatively, with plywood or metal panels, which are free from defects, disturbing the general appearance. Wooden surfaces shall have a sealed surface.

Class B formwork shall be used for the inside of water tanks for other but potable water.

Class C: Finish for surfaces, which are not exposed to view. The formwork shall consist of boards, sheet metal or any other material, which shall prevent the loss of materials during placing and vibrating of concrete.

Where the class of finish is not specified, the concrete shall be finished in accordance to the requirements of class C surfaces.

7.3.5.7 Erection of Formwork

All formwork shall be constructed, firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete. Formwork shall not be tied to or supported by reinforcement.

Faces of formwork in contact with concrete shall be free from adhering matter, projecting nails and the like, split or other defects, and shall be clean and free from stagnant water, dirt, shavings, chippings or other foreign matter. Joints shall be sufficiently water tight to prevent the escape of mortar or the formation of fins or other blemishes on the face of the concrete.

Formwork in contact with concrete shall be treated with suitable non-staining mould oil prior to reinforcement and concrete placement to prevent adherence of the concrete. Care shall be taken to prevent the oil from coming into contact with the reinforcement or with concrete at construction joints. Surface retarding agents shall not be used unless approved by the Engineer.

Where ties are built into the concrete for the purpose of supporting the framework, the whole or part of any such support shall be capable for removal in such a way that no part remains embedded nearer than 5.0 cm from the surface. Holes left after the removal of such supports shall be neatly filled with well-rammed dry-packed mortar.

7.3.5.8 Tolerances

The permissible tolerances in the finished faces of shuttered concrete shall, if not otherwise directed, not exceed the following values:

Type of concrete works:	buried concrete	exposed concrete
Deviation from alignment:	50 mm	10 mm
Deviation from grades:	10 mm	10 mm
Deviation from dimensions:		+10/-5 mm
+10/-5 mm		

7.3.5.9 Removal of Formwork

Formwork shall be designed as to permit easy removal without resorting hammering or levering against the surface.

The period of time elapsing between the placing of the concrete and the striking of the formwork shall be as approved by the Engineer and shall be in any case not less than the period stated in DIN 1045. If not otherwise directed, the striking times for formwork shall be as follows:

- Class of Cement: CEM I 32,5
- Side formwork for beams, walls, columns: 3 days
- Formwork for floor slabs: 8 days
- Formwork for beams, frames and long span slabs: 20 days

7.3.6 Joints

7.3.6.1 Construction Joints of Watertight Concrete

7.3.6.1.1 Definition

A construction joint is defined as a joint in the concrete introduced to the convenience of execution and at which special measures have to be taken to achieve subsequent continuity without provision for further relative movement.
Any construction joint shall be fitted out with a central waterstop, and with a sealant fillet in a groove if required elsewhere.

7.3.6.1.2 Material of bonding agent

Contractor to submit specifications for approval to Engineer; primer and bonding agent to be from the same family of products offered by the same manufacturer.

7.3.6.1.3 Material of sealant for grooves

Prior to ordering the sealant material, the Contractor shall submit to the Engineer for approval sufficient data to show general compliance with the specification requirements. No material shall be acceptable which has an unsatisfactory history as to bond or durability when used in the joints of hydraulic structures. Primer and sealant shall be from the same family of products offered by the same manufacturer.

The sealant shall be two-pack polyurethane polymer specially designed for bounding to concrete continuously submerged in water and shall meet the following requirements:

Work life 45-90 mins. Time to reach "All hardness (at 25°C, 200 gr quantity) 20 hrs max.

Ultimate hardness	20-40 shore "A"
Tensile strength	16 kg/cm² min.
Tear resistance:	120 kg per cm of thickness

Alternatively, a two-pack polysulphide may be used as a sealant.

Certified test reports from the sealant manufacturer on the actual batch of material being supplied indicating compliance with the above requirements shall be furnished to the Engineer before the sealant is used on the job.

The primer and sealant shall be placed strictly in accordance with the recommendations of the manufacturer, taking special care to properly mix the sealant prior to application. Before any sealant is placed, the persons carrying out the work shall be carefully instructed as to the proper method of application.

All sealant shall cure at least 7 days before the structure is filled with water.

7.3.6.1.4 Material for PVC or polymer central water stops

Central water stops shall have 10 mm thick webs and be extruded from an elastomeric Polyvinylchloride compound containing the necessary plasticisers, resins, stabilisers and other materials necessary to meet the requirements of these Specifications. No reclaimed or scrap material shall be used.

The water stop manufacturer shall furnish to the Engineer current test reports and a written certification that the material to be supplied meets the following physical requirements:
Value

7.3.6.1.5 Physical property, sheet material

Tensile strength	- min [kg/cm2]	120
Ultimate elongation	- min [%] 350	
Stiffness in flexure	- min [kg/cm2]	28

7.3.6.1.6 Accelerated extraction

Tensile strength	- min [kg/cm2]	105
Ultimate Elongation	- min [%] 300	
Finished waterstop:		
Tensile strength	- min [kg/cm2]	100
Ultimate elongation	- min [%] 280	

Prior to use of the waterstop material in the field, a cross section sample of a fabricated waterstop of each size or shape to be used shall be submitted to the Engineer for approval.

7.3.6.1.7 Field splices of central waterstops

Field splices and joints shall be made in accordance with the waterstop manufacturer's instructions using a thermostatically controlled heating iron. These samples shall be fabricated so that the material and workmanship represent in all respect the fittings to be furnished under this contract. When tested, they shall have a tensile strength across the joints equal to at least 42 kg/cm².

7.3.6.1.8 Material of steel plate central waterstops

Central steel plate waterstops shall be of black mild steel and shall be a thickness between 3- and 5-mm. Adequate means shall be provided for anchoring the waterstop in concrete. In placing such waterstops in the forms, means shall be provided to prevent them from being folded over by the concrete as it is placed.

Horizontal waterstops shall be held in place with continuous supports to which the top edge of the waterstop shall be tacked.

Vertical waterstops shall be held in place with light wire ties at 45 cm centres, which shall be passed through the edge of the waterstop and tied to the two curtains of reinforcing steel.

7.3.6.1.9 Execution

Concrete placed to form the face of a construction joint shall have all laitance removed and the large aggregate exposed prior to the placing of fresh concrete.

The laitance shall wherever practicable be removed when the concrete has set but not hardened by spraying the concrete surface with water under pressure or brushing with a wire brush sufficient to remove the outer mortar skin and expose the large aggregate without being disturbed.

Where the laitance cannot be removed due to hardening of the concrete, the whole of the concrete surface forming the joint shall be treated by high pressure water jet, sand blasting, use of a needle gun or a scaling hammer to remove the surface laitance.

When placing concrete around waterstops, concrete shall be worked under the waterstops by hand so as to avoid the formation of air and coarse aggregate pockets.

Where grooves are to be provided, the profiles used for forming the grooves shall be left in the grooves until just before the grooves are cleaned, primed and filled with joint sealant. After removing the form from the grooves, all laitance and fins shall be removed and the grooves shall be sandblasted.

The grooves shall be allowed to become thoroughly dry, after which they shall be blown out, immediately thereafter, they shall be primed and filled with the construction joint sealant.

7.3.6.2 Expansion and Contraction Joints, General

7.3.6.2.1 Definition

An expansion or contraction joint serves to absorb the relative movements of adjacent structures and is described on the drawings. Any expansion or contraction joint shall be fitted out with a central waterstop, a joint filler and sealant finish that can follow the relative movement.

Such joints for expansion and contraction shall be constructed in accordance with the details and to the dimensions shown on the approved drawings or where otherwise ordered by the Engineer and shall be formed of the elements specified.

The Contractor shall pay particular attention to the effects of climatic extremes about the works on any material which he may desire to use in any movement joints and shall submit for approval by the Engineer his proposals for the proper storage handling and use of the said materials having due regard to any recommendations in this connection made by manufacturers.

7.3.6.2.2 Material of bonding agent

Same as under 7.3.6.1.

7.3.6.2.3 Material of waterstops

Central Waterstops shall be of PVC exclusively and conform to the requirements specified before and elsewhere.

All waterstops in one structure shall be of the same material.

Waterstops shall be supplied by the longest practical units from the supplier's works and shall be continuous throughout the structure below highest water level. Intersections and joints shall be factory made where possible.

Waterstops shall be carefully maintained in the position and supported on accurately profiled stop boards to create rigid conditions.

7.3.6.2.4 Material of joint filler

Joint filler shall be either cork/bitumen joint filler or cellular joint filler. Cork/bitumen joint filler shall be waterproof and rotproof and shall not extrude as a result of compression. Cork joint filler shall compress to less than 50% of its original thickness with immediate recovery to 80% or more of its original thickness.

Cellular joint filler shall be used only for joints of low horizontal loading and shall be a pre-formed low compression joint filler made from foam rubber. Cellular joint filler shall recover to its original thickness after each loading and unloading.

7.3.6.2.5 Execution

Preparation of concrete surfaces shall be applicable as under 7.3.6.1.

The joint filler shall be fixed to the required dimensions of the joint cross section and shall provide a firm base for the joint sealer. Where the depth of joint between the concrete surface and the water stop does not exceed 500 mm filler shall be placed in single depth sections.

Sealing of expansion joints shall be carried out only when adjacent concrete surfaces are perfectly dry and as long after the concrete has been set as possible. Immediately before the application of the joint sealer the groove protection batten shall be removed in such lengths as represent a single day's work for sealing the joints.

The joint grooves shall be cleaned, adequately primed and filled with approved sealer strictly in accordance with the manufacturer's instructions and on joints of 25 mm and larger with a shape factor of 2:1 (width to depth).

On permanently exposed areas of structures joint sealing is to be carried out with the aid of masking tape to form neatly defined surface limits to the sealer.

7.3.6.3 Sliding Planes

Sliding planes on the concrete and joint blinding layers shall consist of a bitumen sand mixture 1 to 4 by volume spread evenly 3 mm thick over the carpet coat or of building paper either of which shall be applied immediately before the structural floor is concreted and shall be at all times suitably protected. Where building paper is used the concrete formation carpet shall be finished with a steel trowel to give a smooth surface.

Sliding joints shall consist of two layers of purpose made preformed plastic membrane which when in contact shall give a coefficient of friction of not more than 0.2 when subjected to a load

of 270 kg/m2. Where formed in concrete structures the lower joint bedding surface shall be steel float finished to a smooth true surface.

7.3.7 Concreting

7.3.7.1 Preparing for Concreting

For the preparation of concreting, the following shall apply:

No concrete shall be placed until all formwork, installation of reinforcement and parts to be embedded and preparation of surfaces involved in the placing have been approved by the Engineer.
Each surface shall be free from mud and debris and be thoroughly wetted by sprinkling prior to the placing of any concrete.
For watertight structure all slabs, beams and walls shall be concreted in one batch.

Before any lift of concrete is placed, the Contractor shall carry out an inspection to ensure that all preparations are complete, including the provisions of the necessary equipment and personnel and shall ensure that sufficient materials are available to complete the works proposed.

7.3.7.2 Transporting and Placing

Concrete shall be transported from the mixer to its place in the works as rapidly as possible by methods, which shall prevent segregation or drying out and ensure concrete of the required workability at the time of placing:

Concrete shall not be placed when unsuitable wind and temperature conditions prevent proper placement and curing as determined by the Engineer.
Concrete shall be placed by hoppers and chutes and, if necessary, by vertical ducts;
The free fall of concrete after chutes and ducts shall in no case exceed 1.5 m;
Concrete shall not be dropped through any reinforcement or into any deep form in order to avoid segregation
Concrete shall be placed and compacted before the initial set has occurred and, in any event, not later than 45 minutes from the time of mixing.

The concrete shall be placed in the presence of the Engineer or his representative, unless agreed otherwise. The Contractor shall notify the Engineer by writing 24 h prior to the placing of any concrete.

The order of placing in all parts of the work shall be subject to the approval of the Engineer.

In order to minimise the shrinkage, the concrete shall be placed in units as bounded by construction joints. The placing of the units shall be done in such a way, that each unit shall have cured for at least 7 days before the continuous units are placed, with the exception of walls which shall be placed not before the wall footings or adjacent wall panels have cured for at least 14 days.

Whenever a run of concrete is stopped or completed, the surface of the concrete shall be levelled with a trowel and all laitance shall be removed.

Concrete, which is, before placing, found not to be conform to the requirements shall be rejected and immediately removed from the site. Concrete which is not placed in accordance with the above requirements, or which is found to be of inferior quality as determined by the working drawings shall be removed and replaced by and at the expense of the Contractor.

Concrete placing shall not be permitted if, in the opinion of the Engineer, the Contractor does not have proper facilities available on site for placing, curing and finishing the concrete in accordance with these specifications.

7.3.7.3 Compaction

As concrete is placed in forms or in excavations, it shall be thoroughly settled and compacted, throughout the entire depth of the layer which is being consolidated, into a dense, homogenous mass, filling the form completely, thoroughly embedding the reinforcement, eliminating air and aggregate pockets and bringing only a small amount of excess water to the surface of concrete during placing.

For compaction the Contractor shall use power driven vibrators supplemented by hand spading and tamping, except as otherwise approved by the Engineer.

A sufficient number (including stand-by) of appropriate sizes vibrators shall be at all times available on Site.

7.3.7.4 Attendance of Steel Fixer and Carpenter

When concreting reinforced concrete, a competent steel fixer and carpenter shall be in attendance on each concreting gang to ensure that the reinforcement, formwork, spacers and embedding fittings are kept in position as works proceed.

7.3.7.5 Concreting in Hot Weather

The temperature of concrete as placed shall not exceed 30°C in order to prevent rapid drying of the newly placed concrete. To achieve this, the Contractor shall provide sunshades over aggregate stockpiles cement silos and mixing water tanks and preferably place concrete during the night hours.

With the approval of the Engineer, also the following procedures may be applied:

Cooling of mixing water by chipped ice;
Sprinkling of stockpiles with water
Shade or wet the outside of the formwork.

The fresh concrete shall be shaded and cured as soon as the surface of fresh concrete is sufficiently hard.

7.3.7.6 Concreting in Cold Weather

Given cold weather and frost, the concrete must be of certain minimum temperature when being brought into place.

At ambient temperatures of between + 5°C and - 3°C the temperature of concrete used may not be lower than +5°C.

If the content of cement is lower than 240 kg/m³, the temperature of the concrete may not be lower than + 10°C.

At ambient temperatures of below - 3°C the temperature of the concrete used must be at least + 10°C and must subsequently be kept at this temperature (+ 10°C) for at least 3 days.

With the approval of the Engineer, also the following procedures may be applied:

Warm the mixing water and possibly also the aggregates; the temperature of the unset concrete may not exceed + 30°C (aggregates shall not be used when they are frozen);
Use of heat insulating shuttering;
Delayed stripping of formwork;
Enclosing the building works with canvas shelters
Addition of heat; during this process the water necessary to harden the concrete may not be withdrawn.

It is allowed to add concrete to frozen concrete parts and concrete damaged by frost has to be removed before concreting continues.

7.3.7.7 Curing of Concrete

All concrete shall be cured by protecting the surface from the effects of sun, drying winds, rain, running water or mechanical damage for a continuous period of at least seven days by:

Keeping wooden formwork wet until it is removed;
Covering the concrete surface with burlap mats and keeping them wet;
Covering the surface with moist earth (not before 4 h and not longer than 24 hours after concreting);
Spraying the surface with water or a liquid curing compound.

7.3.7.8 Care and Repair of Concrete

The Contractor shall protect all concrete against injury or damage from excess heat, lack of moisture, overstress or any other cause until final acceptance by the Engineer.
Any concrete found to be damaged, which may have been originally defective, which becomes defective prior to the final acceptance of the completed work or which does not conform to the Specification, shall be satisfactorily repaired or removed and replaced by the Contractor at his own expense.
Repair of concrete must be made by a proper mortar which is designed for only repair purposes. For example, SIKA Monotop 610 – 604 – 620 (or similar products) are three chemicals which are used all together for repair works of concrete.

Mortar for concrete repair works must be approved by the Engineer prior to the commencement of any repair works.

7.3.7.9 Finish of Concrete Surfaces

Workmanship in formwork and concreting shall be such that concrete does not require making good, i.e. surfaces are perfectly compacted, smooth and with no irregularities. Surfaces shall be free from fins, bulges, ridges, offsets, honeycombing or roughness of any kind.

Except if otherwise provided, unformed top surfaces of concrete shall be brought to a uniform surface and worked with suitable tools to a smooth wood-float finish. Excessive floating of surfaces while the concrete is plastic shall not be permitted.

As soon as forms are removed, all exposed surfaces shall be carefully examined and any irregularities shall be immediately rubbed or ground in a satisfactory manner in order to secure a smooth and uniform surface.

Plastering or coating of surfaces shall not be permitted. No repairs shall be made until after inspection by the Engineer and then only in strict accordance with his directions.

Concrete containing voids, holes, honeycombing or similar depressions shall be completely removed and replaced.

7.3.7.10 Building-in Pipes and Equipment

Where possible, pipes shall be installed and built into the structures as work proceeds. Otherwise, appropriate blockouts shall be provided.

Individual pipes of a complex pipe system shall not be built into the concrete structures before accurate fitting of the whole system. Where blockouts are required, these shall be of size and shape sufficient to permit proper placing and compaction of concrete or grout. The surfaces shall be treated to produce a bonded surface before installation of plant.

Before building-in commences the pipe or plant shall be adequately supported in position to prevent movement or damage during building-in. Concrete used for building-in shall be of the same class as concrete of the part of work into which the plant is built. Concrete, mortar and grout shall be carefully placed and compacted around the plant to avoid damaging or moving the plant.

7.3.7.11 Puddle Flanges and Pipe Supports

Puddle flanged fittings for building into the walls may be the single-flanged type. Where the single-flanged type is used it shall be positioned so that the puddle flange is in the centre of the wall. Where the double-flanged type is used it shall be positioned so that the outside face of each flange is flush with the face of the wall.

The Contractor shall provide pipe plinths where necessary in chambers to support the pipe adequately, both during and after construction.

The Contractor shall be entirely responsible if damage is caused to pipes because of his failure to provide adequate supports. Support blocks shall be made from C 20/25 concrete or a higher grade.

7.3.7.12 Prefabricated Concrete Member

Prefabricated concrete member shall be obtained from an approved manufacturer or prepared by special skilled employees and shall be true to dimension and shape, with true arises and with perfectly smooth exposed faces free from surface blemishes, air holes, crazing or other defects, whether developed before or after building-in.

The concrete shall comply in every respect with the provisions of the contract whether such units are manufactured on the site or obtained from other manufacturers.

All cement, aggregate and other materials for precast concrete units with faces, which are exposed whether internally or externally, shall be from the same sources throughout.

Exposed surfaces of the units shall be uniform in colour and in texture.

Formwork and unformed surfaces for prefabricated concrete members shall comply generally with the accuracy grade "C" according to DIN 18202.

7.3.7.13 Pre-stressed Concrete

Pre-stressed concrete work whether prefabricated or cast in-situ shall be as detailed on the approved drawings and the Contractor shall provide full details of his proposed method of carrying out all operations connected with pre-stressing including:

Design of concrete mix; description of concrete casting and curing operations;
Procedure for pre-stressing and method of checking and recording the pre-stressing wire extension and anchorage slip
Procedure for handling, hoisting and placing of any pre-cast units;
Grouting of ducts.

All tendons, duct forming devices, anchorages and other components shall be kept free of mud, oil paint, retarders, loose rust or other foreign matter. They shall be placed with a tolerance of ± 3 mm in concrete dimensions of 300 mm or less or ± 6 mm in concrete dimensions over 300 mm.

The bearing surfaces between anchorages and concrete shall be normal to and concentric with the tendons and the line of action of the pre-stressing force.

7.3.7.14 Concrete for Benching

Concrete benching in manholes and works structures shall consist of granolithic concrete which is formed of 1 part of cement, 1 part of dry fine aggregate and 2 parts of dry coarse aggregate. Coarse aggregate must be 10 mm crushed lime stone and fine aggregate must comply with gradings C or M of B.S. 882 Table 5. It shall be placed with low workability to the approximate shape required and, while still green, shall be finished with not less than 50 mm of granolithic concrete to a steel trowelled finish and to the contours indicated on the drawings.

7.3.7.15 Pumping Concrete

Where pumping of concrete is permitted to be used, no relaxation of the requirements of this Specification shall be permitted.

Particular attention shall be paid to the proper grading of aggregates to prevent bleeding and/or segregation during the pumping operations.

The inclusion of water-reducing additives or other materials, including fly ash, to improve the flow characteristics of the concrete shall only be permitted where it can be shown that they do not adversely affect the concrete either in the plastic phase or in the finished work.

7.4 Road Works

7.4.1 General Requirements

Road works, as specified hereunder, shall include the construction or reinstatement of roads and pavements as shown on the drawings or as directed by the Engineer.

Earth works are not covered by this chapter.

All materials shall be new and shall comply with standard quality and dimension provision.

For non-standardised materials and building components the Contractor shall, on demand of the Engineer, supply samples and name of manufacturer, and shall be subject to the approval of the Engineer.

Mineral materials shall be weatherproof, of adequate hardness and of sufficient adhesion to bind. They shall not contain any swelling, weathering, loamy, clay or organic components in harmful quantities.

Bituminous mixes shall be blended so as to be suitable for the purpose of application. Special consideration shall be given to climatic conditions, volume and type of traffic.

7.4.2 Maintenance and Reinstatement of Existing Roads and Footpaths

The Contractor shall maintain existing roads and footpaths within the Site. He shall reinstate the pavements, curbs and other parts of the roads after execution of works to its original state.

The Contractor shall remedy any settlement occurring after execution of works immediately upon notification by the Engineer.

Such remedy of pavement shall be done at the Contractor’s own expense and shall include the re-excavation of the top surface, base and sub-base, the backfilling of base and sub-base with graded aggregate and the reinstatement of the surface.

7.4.3 Sub Grade

Sub grade shall be graded and compacted to the levels, falls, cambers as required by RSTO-01 (German Technical Code for Construction of Paved Road Surfaces) and shall be compacted that the dry density of the upper 15 cm of the ground or fill is not less than 95% of the maximum dry density determined by tests in accordance with DIN 18127. Where the sub grade is the natural soil, compaction shall be carried out at or near to the natural moisture content of the ground.

Material not suitable to reach the required density shall be removed and replaced with material for granular sub base.

Surface of subgrade shall be kept free of standing water at all times and drains shall be provided so that it shall drain quickly and effectively during rain.

Any irregularities or depressions that develop during compaction of the sub grade or any area which becomes muddy, broken-up or loosened due to weather conditions shall be corrected by loosening the surface of these places and adding, removing or replacing these materials and re-compacting so that the surface is smooth and uniform.

7.4.4 Pavement

7.4.4.1 Sub-Base and Road Base

The sub base and road base shall be graded and compacted to the levels, falls, cambers and densities as required by RSTO-01 or as shown on drawings.

The materials for sub-base and road base shall be laid in layers, each not exceeding 15 cm or being less than 10 cm. The total compacted thickness of sub-base and road base shall nowhere be less than the specified nominal thickness. If not otherwise directed, the sub-base and base in roads shall have each a thickness of 20 cm, in footpaths a thickness of 15 cm.

The sub-base and road base materials shall be deposited in such a manner that there is no segregation and the materials require the minimum of blading or spreading. Each layer of material shall be compacted immediately after spreading in accordance with ZTVE-StB. 94 (German Technical Code of Practice for Earthworks for Roads).

If any of the sub grade material is worked into the sub base material during spreading, profiling or compaction, all the sub base material in the affected area shall be removed, the sub-grade compacted again and fresh sub base material shall be placed all at the Contractor's expense.

On completion of compaction and before commencing the next operation, the surface of the granular sub base and road base shall comply with a surface tolerance of +/-1 cm.

7.4.4.2 Surfacing, general

Wherever possible, the operations of final trimming of the formation, compaction of the sub grade and placing and compaction of the granular sub-base and road base shall be carried out immediately one after another.

The Contractor shall take all necessary steps to prevent damage to the previously completed layer or layers by excessive wetting or drying out due to weather conditions or by traffic or any other cause. If the contractor considers it as advisable or if so ordered by the Engineer, the completed layers shall be sealed using bitumen road emulsions.

In any case, the completed surface of the road base shall be sealed with suitable emulsion (M.C.70) at a rate of 1.5-2.0 kg/m² immediately when it has been completed and checked for compliance with the specified tolerances.

7.4.4.3 Flexible Pavement

Unless otherwise specified or detailed, materials for flexible pavement shall be bituminous concrete and asphalt, in a quality corresponding to the relevant sections of DIN 18315 to DIN 18318. The surface on which each course of coated bituminous material to be laid shall be free from standing water and any loose or deleterious material and shall be tested for accuracy.

Before laying commences in any area, a tack coat of bitumen road emulsion shall be applied to the whole area of the preceding course and any other surfaces with which the coat shall be in contact.

After cleaning, the top of the base shall be sprayed with suitable emulsion (M.C.70) at a rate of 1.5-2.0 kg/m²; the surface of the bituminous coat shall be treated with asphalt tack coat (RC-250) at a rate of 0.5 kg/m². The emulsion shall be allowed to break completely before the subsequent bituminous layer is laid on it.

Coated macadam material shall be delivered to site in clean vehicles and shall be covered to minimise loss of heat in transit and against contamination by dust or other deleterious matter.

The rate of delivery to the site shall be regulated so as to enable the material to be laid with the minimum of delay and so that the paver can operate continuously.

The coated thickness of individual layers shall be not less than the minimum compacted thickness specified or shown on the approved drawings. If not otherwise directed, the bituminous base course shall have a thickness of 10 cm, the wearing course of 5.0 cm.

7.4.4.4 Rigid Pavement

Rigid paved areas shall be constructed in concrete in accordance with RStO-2001 and with the relevant requirements of the Specification for Concrete Works.

Concrete for rigid pavement shall be of class C 20/25. The use of additives shall be subject to the approval of the Engineer. Concrete courses shall be never less than 100 mm thick.

Reinforcement shall be of steel mesh of not less than 2 kg/m², unless otherwise approved. The reinforcement shall not influence the effectiveness of the joints. The concrete cover shall be not less than 30 mm..

Transport and placing of the concrete shall be co-ordinated so that the concrete can be completely placed before setting.

Expansion joints shall be executed at the required intervals and shall enable expansion to the concrete slabs and be fixed. The expansion joints shall be 20 mm wide. The strength of the concrete and the properties of the concrete surface shall not be influenced by the execution of joints.

The concrete shall be protected against harmful influences until correct setting, i.e., against drying out, especially due to sun and wind, against washing out due to rain, against heat or quick cooling. The concrete surfaces shall be cured and kept moist for 7 days.

7.4.4.5 Kerbs

Kerbs shall comply with the following Standards:

DIN 482	Natural stone kerbs (for shapes and dimensions)
EN 1343	Kerbs of natural stone for external paving – Requirements and test methods
DIN 483	Concrete kerb units – Shapes, dimensions, marking
EN 1340	Concrete kerb units - Requirements and test methods

Kerbs shall be flayed true to line and level. Kerbs found to be more than 1 cm out of line or level at either end shall be lifted and relied.

Kerbs shall be bedded on a layer of 3:1 sand/cement mortar, minimum 10 cm thick on a grade C 8/10 concrete foundation and shall be backed with concrete shaped up to the required cross section. Kerbs shall be jointed with cement mortar except at expansion joints, which shall be made with joint filler, 10 mm thick.

7.4.4.6 Footpaths

Footpaths shall be surfaced with coated macadam, concrete, pre-cast concrete slabs or natural stones. The base for footpaths shall be formed from flexible surfacing, laid and compacted to a minimum thickness of 100 mm using a roller of at least 2 tons mass or other approved equipment allowing for equivalent compaction.

Where footpaths receive coated macadam surfaces, the construction shall be as follows:

pre-cast concrete edging in accordance with appropriate the Standards as mentioned above shall be bedded and backed with in-situ concrete C 8/10;
the base shall be constructed as specified above and shall then be sealed;
the surfacing shall consist of a single course of coated macadam and be compacted to minimum thickness of 25 mm.

Pre-cast concrete slabs shall be bedded on a layer of sand, of thickness not less than 50 mm, and tamped into place.

Natural stones shall be sound, durable, hard and free from undesirable weathering and shall be of such properties that they shall not disintegrate from the action of weather in handling and placing.

The density of stones shall be not less than 2.2 t/m³ (solid volume without voids).

The dimensions of stones shall range between 150 and 200 mm.

The stones shall be rough hammered dressed so that they fit reasonably close together.

They shall be laid to a true and even surface on a layer of sand, approximately 100 mm thick and tamped into place.

Concrete footpaths shall be surfaced with concrete C 20/25, at least 10 cm thick with mortar topping, constructed on a prepared bed as specified above and in accordance to the Specification for Concrete Works.

7.4.4.7 Disposal of Surplus Material

Unless otherwise directed by the Engineer, the Contractor shall make his own arrangements to dispose off all surplus backfill and unsuitable excavated material from any part of the Work.

The material shall be disposed off-site and shall become the property of the Contractor who shall be entirely responsible for its removal from the Site and its ultimate disposal.

The Contractor shall clean the Site and the surrounding ground immediately and leave the construction sites clean and tidy to the satisfaction of the Employer.

7.5 Drainage Works

7.5.1 Piped Systems

Circular concrete pipes and fittings shall be "standard" quality with approved flexible spigot and socket joints and shall comply with EN 1916 and DIN V 1201.

Glazed vitrified clay pipes and fittings shall conform to EN 295 or equivalent and not be used for diameters exceeding DN 300. PVC pipes and fittings shall conform to EN 1401 or equivalent and not be used for diameters exceeding DN 500.

Manholes and inspection chambers shall conform to EN 1917 in conjunction with DIN V 4034 or equivalent. Gullies shall comply with DIN 4052 or equivalent. Manholes, inspection chambers and gullies shall be constructed in details as shown in the standards.

Cast iron covers or gully gratings shall be of Class D 400 according to EN 124. Manhole covers shall comply with DIN 19584. Gulley grating shall comply with DIN 19583.

Earthworks for piped drainage systems shall be carried out in accordance to the Specification of Earth Works, applying minimum cover and trench width.

7.5.2 Open Channels

Open channels shall be constructed either as earth channels, in stone work or with pre-cast concrete elements in half-round or trapezoidal sections.

Open channels adjacent to buildings, basins or other structures and channels with longitudinal slope steeper than 1:100 shall be constructed with pre-cast concrete or stone work, depending on soil conditions. Channel sections, which are subject to scouring, shall be protected with stone pitching.

Pre-cast concrete channels shall be manufactured of pre-cast concrete class C 20/25. All backfilling shall be with selected approved material. If the soil is unsuitable for laying of channels, the Contractor shall place a bedding layer of approved granular material or concrete C 8/10 under the channel.

All road crossings of channels shall be constructed such that vehicular traffic is not exposed to danger.

The Contractor shall provide for the installation of pipes and culverts or grating over the channel.

7.6 Building Works

7.6.1 General

7.6.1.1 Scope

This sub-section covers the requirements for the construction of buildings and includes all building works, except earth and concrete works. The work required under this sub-section shall include all labour, materials, equipment, remedy of deficiencies, site clearance and all other appurtenant works required to complete all building works specified herein.

7.6.1.2 Standards and Rules

The Contractor shall carry out the works described in this Section in accordance with the appropriate DIN standards or equivalent standards. The main standards are, but are not limited by, the following:

DIN	18330	Masonry works	DIN	18352	Tiling
DIN	18331	Concrete and reinforced concrete	DIN	18353	Screeding works
DIN	18332	Natural stonework	DIN	18354	Bituminous paving
DIN	18333	Artificial stonework	DIN	18355	Joinery
DIN	18334	Carpentry	DIN	18361	Glazing
DIN	18336	Waterproofing against moisture	DIN	18363	Painting works
DIN	18337	Waterproofing against pressurised water	DIN	18365	Flooring
DIN	18338	Roofing	DIN	18379	Ventilation works
DIN	18339	Plumbing works	DIN	18381	Sanitary installation
DIN	18350	Plastering			

7.6.1.3 Works Included

The Contractor shall, unless otherwise specified herein, supply all materials, equipment, temporary works and labour necessary to perform, maintain and complete the building works.

7.6.1.4 Works to be Measured

Building works under the present Contract shall be quoted as a lump sum for the various sections of work. Payments for the completed sections of work will be made in accordance to the provisions made in the Particular Conditions of Contract.

7.6.1.5 Approval of Materials and Workmanship

The supply of all materials and items shall be subject to the approval of the Engineer. The Contractor shall provide such samples as the Engineer may require in advance for the approval

and, when approved, the quality of materials and workmanship shall be at least equal to the approved samples.

7.6.2 MASONRY WORKS

7.6.2.1 Materials

7.6.2.1.1 Bricks and Blocks

Bricks shall be clay facing bricks manufactured locally. The quality shall correspond to DIN 105. Blocks shall be dense concrete blocks in accordance to DIN 18153 with a compressive strength of more than 7.5 N/mm². Bricks and blocks shall be hard, sound, square and clean with sharp, well defined arises.

The Contractor shall submit samples of each type of bricks and blocks used in the works and obtain the Engineer's approval before placing orders with suppliers. Strength test certificates performed on the basis of appropriate DIN standards shall also be submitted on request of the Engineer.

7.6.2.1.2 Reinforcement for Brickwork

Reinforcement of brickwork shall be in accordance with DIN 488, DIN 1045 and DIN 1053. Reinforcement for Brick shall be plain round bars B ST 22/34 GU or ribbed bars B St 22/34. Reinforcement shall be detailed, stored and tested as specified for Concrete Works.

7.6.2.1.3 Fixings for Brickwork

Fixings shall be, if not otherwise specified by the Engineer, of stainless steel for sheet, strip, plate and bars in accordance to DIN 17440.

7.6.2.1.4 Sand

Sand shall be clean and sharp course grit, fresh water river or pit sand conforming in all respects to DIN 1053 and DIN 18550 and shall be re-washed on site if the silt, loam or clay content exceeds the limits prescribed in DIN 4226. The sand shall be obtained from a source approved by the Engineer.

7.6.2.1.5 Cement

Cement shall be sulfate resisting Portland cement as specified in DIN 1164. The source of cement is subject to the approval of the Engineer and shall not be changed without his prior approval.

7.6.2.1.6 Water

For the mixing of mortar and plaster the Contractor shall provide tap water, if not otherwise directed or approved by the Engineer.

7.6.2.2 Mortar Mix

Masonry mortar for setting blocks and bricks shall be of the quality group III set out in DIN 18550. The proportion shall be 1 part cement to 4 parts sand or as otherwise directed or approved by the Engineer. Mortar shall be added to the mix in an amount compatible with workability. Mortar constituents shall be measured by volume using clean gauge boxes.

Mortar shall be mixed in a mechanically operated mortar mixer for at least three minutes after all ingredients are in the drum. The mixing by hand will only be permitted when the quality of hand mixing is comparable to mechanical mixing.

Mortar shall be used within 2 hours after discharge from the mixer at normal temperatures. No mortar shall be used after the initial set has taken place. Reconstitution of mortar will not be permitted.

7.6.2.3 Workmanship

All masonry shall be laid plumb and true to lines and built to the thickness and bond required. Masonry shall be carried up in a uniform manner. No one portion shall be in raise more than one meter above adjacent portions, except with the approval of the Engineer.

Sample panels of 1 m² size shall be prepared for each type of facing brickwork or blockwork, including jointing or pointing, and the Contractor shall not commence facework without the approval of the Engineer. Facework shall be kept clean during construction and until completion of the Works.

Under hot and dry weather conditions, bricks and blocks shall be stacked on a hard-standing level so as to prevent the absorption of water. Suitable shading shall be provided to prevent high temperatures within the brick and block stacks. Clay brickwork and blockwork shall be kept wet to the minimum extent required to prevent mortar drying out prematurely.

Freshly laid brickwork / blockwork shall be protected during interruption through rain and at the completion of each day’s work.

Facework shall be kept clean during construction and until practical completion. Scaffold boards shall be kept clear of the building at night and during heavy rain. Rubbing to remove stains will not be permitted.

All bricks shall be wetted before being laid.

Clay bricks shall not be used until completely cold from the kiln.

Facing bricks of varying colour shall be distributed evenly throughout the work so that no patches appear. Different deliveries, which vary in colour, shall be mixed to avoid horizontal stripes.

Brickwork and blockwork abutting concrete columns, walls and beams shall be tied with stainless steel ties in accordance with the relevant references and as directed by the design. Additional ties shall be supplied at openings. Walls which are to be fair face shall have selected bricks and blocks with perfect arises and flat surface structures and with faces in line

7.6.2.4 Exposed Concrete Blocks

Concrete blockwork shall be laid in stack bond and, unless otherwise directed, with joints not exceeding 1 cm and uniform throughout. All blocks shall be laid in a full bed of mortar applied to shells only. Intersecting bearing walls shall be tied together with stainless steel ties at one meter vertical spacing.

Where directed, concrete blocks shall be reinforced and concrete blocks lintel type shall be built in above wall openings.

Control joints shall be installed at the intersection with structural concrete and elsewhere where joints are useful. Joints not detailed otherwise shall be racked out to a depth of 2 cm for the full height of the wall and be caulked. Joints are to be examined to locate cracks, holes or other defects and all such defects shall be remedied with mortar and pointed.

7.6.2.5 Concrete Blocks to Receive Plaster

Concrete block walls to be plastered may be laid with bonds described above. Joints are to be left rough to assist in bounding of plaster. Control joints in plastered block shall be carried through the plaster. The joint shall not be plastered.

7.6.2.6 Brickwork

Solid brick walls shall be laid in common bond with all joints filled solidly with mortar and backs fully purged to form solid masonry structure. Joints of walls to receive plaster shall be lightly raked to provide a bond for plaster. Control joints in brick walls shall be carried through the plaster. The joint shall not be plastered.

7.6.2.7 Lintels, Miscellaneous

The Contractor shall build in or provide all miscellaneous items to be set in masonry including lintels, frames, reinforcing steel, electrical boxes, fixtures, sleeves, grilles, anchors and other miscellaneous items. All anchorage, attachments and bonding devices shall be completely covered with mortar.

7.6.2.8 Cleaning

Masonry work to be exposed shall be thoroughly cleaned. Mortar smears and droppings on concrete block walls shall be dry before removal with a trowel. Masonry work may be cleaned using a mild muriatic acid solution.

7.6.2.9 Damp-proof Courses

As a minimum requirement, damp-proof courses shall be in accordance with DIN 4117 and DIN 4122.

Bituminous sheet damp-proof courses shall be laid on a level bed of cement mortar with a minimum lap of 75 mm at angles and joints and neatly pointed in matching mortar on exposed edges. Horizontal and sloping damp-proof coursing over door openings shall be in single pieces of material of a length to extend 225 mm at both sides beyond the width of the frame.

7.6.2.10 Waterproof Building Paper

Waterproof building paper shall be laid beneath structural concrete. The paper shall be laid with 150 mm lapped joints, which shall be treated and sealed with an approved bituminous solution. The weight of the paper shall not be less than 0.3 kg/m².

7.6.3 Plastering

7.6.3.1 Materials

7.6.3.1.1 Sand

Sand shall be clean and sharp course grit, fresh water river or pit sand conforming in all respects to DIN 1053 and DIN 18550 and shall be re-washed on site if the silt, loam or clay content exceeds the limits prescribed in DIN 4226. The sand shall be obtained from a source approved by the Engineer.

7.6.3.1.2 Cement

Cement shall be sulphate resisting Portland cement as specified in DIN 1164. The source of cement is subject to the approval of the Engineer and shall not be changed without his prior approval.

7.6.3.1.3 Water

For the mixing of mortar and plaster the Contractor shall provide tap water, if not otherwise directed or approved by the Engineer.

7.6.3.2 Plaster Mixing

Plaster shall be mixed with proportions according to DIN 18550. The constituents shall be measured by volume and water added in an amount compatible with workability.

Plaster shall be mixed in a mechanically operated plaster mixer for at least long enough to make a thorough, complete intimate mix of the materials. The mixing of plaster by hand shall not be permitted, unless otherwise directed. The mixer, bunker, gauge boxes and all tools shall be kept clean, and care shall be taken to ensure that fresh plaster is not contaminated with set plaster.

7.6.3.3 Workmanship

Plaster shall be of 2 or 3 coats. If plaster is to be applied to smooth surfaces, a dash coat shall be applied as a bonding surface. The dash coat shall be of mush consistency, composed of 1 part Portland cement and 1.5 parts of sand. The plaster coats shall be applied with the thicknesses given below; notwithstanding additional thickness being required in case of unevenness in the masonry surface

Location:	Ceiling	Interior wall	Finish
Thickness of first coat:		15 mm	10 mm 10 mm
Thickness of intermediate coat:		--	6 mm 9 mm

Thickness of finish coat:	10 mm	4 mm	6 mm
Total thickness:	25 mm	20 mm	25 mm

7.6.3.4 Preparation of Surfaces

The Contractor shall carefully examine surfaces that are to receive plaster and any unsatisfactory surface shall be repaired as directed by the Engineer. Where fixtures have to be installed prior to plastering they shall adequately be protected from damage during plastering. Concrete masonry and brick surfaces shall have sufficient roughness to provide proper bond and shall be dumped by brushing or spraying with water followed by plastering.

7.6.3.5 Plastering

The dash coat shall be applied with a whisk broom or fibre brush and be kept moist for 48 hours before the first coat is applied to the dash coat.

Before the first coat hardens, the surface shall be scratched to provide bond for the intermediate coat. This coat shall be kept moist for not less than 24 hours and be allowed to set for not less than 14 days before application of the intermediate coat.

The surface of the intermediate coat shall be brought to a true and even surface, then roughened with a wood float before setting to provide a bond for the finish coat.

The finish coat shall be applied while the intermediate coat is moist and if the intermediate coat dries out it shall be wetted evenly. The finish coat shall be first floated to a true and even surface and then trowelled to a smooth and even finish.

7.6.3.6 Completion of Work

Completion of work includes curing (moisturising for at lest 3 days) and removal of deficiencies (at the Contractor's expense). Upon completion of the work, all plaster surfaces shall be cleaned and all rubbish, debris and excess material and equipment shall be removed.

7.6.3.7 Waterproof Plaster

Waterproof plaster shall consist of waterproofing compound, cement and sand mixed in strict accordance with the manufacturer's specification. The water proofing compound shall be a mass product of a repudiated manufacturer and shall be approved by the Engineer.

7.6.3.8 Tolerances

All surfaces shall be true to line, level, plumb and all junctions, angles and arises truly scare. On two or three coat work, the plaster surface shall not show any deviation greater than specified in DIN 18202 for accuracy class B.

7.6.4 Screeds

7.6.4.1 General

Workmanship and construction shall generally conform to DIN 18353 and DIN 18560 or equivalent standards.

Materials used for mortar shall be measured in gauge boxes. All concrete surfaces shall be adequately prepared and keyed to receive screeds. The screeds to be carried out have to be placed within buildings and shall be dense aggregate cement screeds.

7.6.4.2 Floor Screeds

Floor screeds in operation buildings shall be laid monolithically to a thickness of 2.5 cm and be laid separately.

The preparation of base concrete shall include the removal of laitance from the concrete surface to receive screed and the removal of all loose concrete, dust and dirt by thorough washing with water.

The screed mix shall be prepared in accordance to DIN 18550 and shall be thoroughly and efficiently be mixed dry by mechanical means until a uniform distribution is obtained prior to adding the water. The water content shall be kept as low as it is necessary to allow for sufficient workability for laying and compacting. Where only small quantities are required, mixing might be carried out by hand on clean watertight surface with the approval of the Engineer.

The screed mix shall be placed between forms, rigidly fixed on a firm foundation and set true to level within +/- 3 mm, and shall be fully compacted by means of a screed board providing laitance is not brought to the surface. The screed wearing course shall be tamped with a wood float and trowelled with a steel trowel to produce a smooth finish.

The screed mix shall be placed between the forms (and or other bays) worked around the penetrations, duct covers, manhole covers, gutters, balustrade standards, pipes, etc., and shall be fully compacted by means of a screed board, or other suitable compacting equipment, providing laitance is not brought to the surface.

7.6.4.3 Joints

All edge joints of floor screeds shall be simple butt joints without filler. Screeds laid over construction joints in concrete shall be separated by 10 mm impregnated oakum strips or the like.

Joints in wearing courses shall be 10 mm poly-sulphide according to DIN 18540.

7.6.4.4 Tolerances

The finished surface of base course screeds shall comply with DIN 18202 accuracy class B.

Floor screeds shall be free of all defects and any work which shows signs of bond failure, hollow patches, crazing, cracking or any other defects will not be accepted and shall be removed and replaced with acceptable work by the Contractor.

The extent of the work to be removed and the method to be used in the removal and replacement of this work shall be to the approval of the Engineer.

The Engineer shall approve all surfaces before continuation of works.

7.6.5 Flooring

7.6.5.1 General

All materials and structural components not covered by **EN standards** or equivalent may be used subject to the Engineer's consent only. The floorings shall be such as to provide a cover surface that can well be walked on and must not give any rise to any unreasonable inconvenience.

7.6.5.2 Materials

Marble shall be first quality in accordance with DIN 52100, matched for colour and pattern. Slabs displaying defects such as stains, chipped edges or corners shall be rejected and in no case incorporated in the works. If not otherwise directed, white marble shall be used for floors.

Concrete paving slabs shall be 50 mm thick, hydraulically pressed pre-cast concrete slabs in accordance with DIN 18500.

Terrazzo shall be in accordance with the appropriate standard. The marble chippings shall be of an approved quality in irregular pieces with no flaky pieces.

PVC flooring material shall comply with the requirements of DIN 16951 and DIN 16952 and shall be temperature resistant, waterproof, abrasion resistant, flameproof, pigment or colour proof to light, evenly coloured throughout, resistant to chemicals, fats, acids and alkalines, odourless, easily laid and flexible, non-porous and slip proof.

All adhesives shall have suitable properties to ensure a firm and durable bond. They must not adversely affect either the flooring nor the underlays or the base and shall be odourless once applied.

All fillers and levelling compounds shall have a firm and durable bond to the base, provide a good bonding surface for the adhesive and be of suitable property so as to give an adequate support to the covering. They must have no adverse effect on base, adhesive, underlay, or covering.

7.6.5.3 Workmanship in General

The Contractor shall examine the base to verify whether it is in suitable condition to carry out his work. He shall communicate any doubts the Contractor may have in this connection, to the Engineer immediately in writing.

All materials and structural components whose processing is subject to manufacturer's instructions shall be processed accordingly. The Contractor shall clean the flooring and treat it in accordance with the manufacturer's instructions for flooring materials.

The Contractor shall furnish the Engineer with the written instructions for the care and the maintenance of the flooring.

7.6.5.4 Preparation of Surfaces

The surfaces must be cleaned prior to flooring. The base for covering to be placed without underlay shall be smoothed with filler compound. In the case of major unevenness a suitable levelling compound shall be used.

Any filler or levelling compound shall be applied so that it will bond firmly and durably to the base, will not crack and will adequately withstand pressure. Any screeds such as magnesia and anhydride screed to which the filler or levelling compound will not sufficiently bond, shall receive a priming coat.

7.6.5.5 General Requirements for Application

Workmanship generally shall be in accordance with DIN 18352 and DIN 18365.

Floorings shall be placed without underlays unless otherwise specified.

The courses shall be laid towards the main window wall, in halls and corridors, however, in longitudinal direction, unless otherwise specified.

Deviations in colour which are not of minor importance and not due to the flooring pattern shall not be allowed if marring the overall appearance of the flooring. Courses with pattern shall be laid so as to suit these.

Where courses run towards doors, recesses and the like, they shall be laid so to cover also the floor areas such door openings, recesses etc. Strips of slabs may be used as coverings of such floor areas.

Plastic flooring shall not be welded unless otherwise specified or expressly required in the flooring material manufacturer’s processing instructions.

Baseboards of the same material as the flooring material with a minimum height of 6 cm have to be installed at all side walls.

7.6.5.6 Marble

Marble slabs shall be stacked under cover, on clean level surface, protected against water penetration from the ground. Units shall be stacked vertically on edge with non-staining laths or battens placed between each unit. To avoid discolouration, panels shall not be prematurely delivered to the site nor come into contact with ropes, staw, hardwood or other materials likely to cause staining, nor shall they be exposed to direct sunlight.

Marble slabs shall be fixed solid on a bed of cement-sand mortar (mix 1:4), 20 mm thick with tight joints grouted in lime putty. A protective slurry of lime putties, at least 3 mm thick, shall be applied to the marble paving and subsequently cleaned off. Slabs shall be laid with staggered joints. Threads to stairs shall be fixed solid on a bed, 15 mm thick. Risers to stairs shall be fixed solid on a backing, 10 mm thick.

7.6.5.7 Precast Concrete Slabs

All pre-cast concrete slabs shall be laid in bays not exceeding 10 m in length, the bays being separated by an expansion joint 10 mm wide.

7.6.5.8 Thin Floor Coverings

Flexible PVC sheeting or tiles shall be laid on a level and smooth background generally consisting of anhydride screed. The screed surfaces shall be clean, dust-free and dry. Tiles shall be laid in strict accordance with manufacturer's instructions.

7.6.6 Tiling

7.6.6.1 General

Tiling shall comprise all required labour, equipment and the supply of the appurtenant materials and structural components including off-loading and storage at the site. Tiling and flooring shall be applied in accordance with the finishes, specified in the Particular Specification. Workmanship and construction for tiles to floors and walls shall generally be in accordance with DIN 18352. All materials and structural components, which are not standardised, shall be used only with the approval of the Engineer.

All tiles and flags for which there are several grades available shall be of the best standard commercial grade, unless grade is stipulated in the Particular Specification. Tiling shall be free of any defects and any work that shows signs of bond failures, hollow patches, misalignment, cracking or any other defect. Defective work shall not be accepted and shall be removed and replaced by acceptable work.

Before starting the work, the Contractor shall ascertain the Employer's selection of patterns and colours and the Contractor shall furnish the Engineer with duplicate samples of the patterns and colours of the materials selected by the Employer.

7.6.6.2 Materials

In general, tiles and flags shall meet the quality requirements of DIN 18155, DIN 18158 and DIN 18166. Where tiles and flags are not standardised, the quality features shall satisfy the standard commercial requirements (top surface, parallelism of edges, colour, and water absorption). All floor and wall tiles shall be from the same batch.

Glazed ceramic tiles for walls shall be in the colour selected by the Employer, true to shape, flat, free from flaws, cracks and crazing, uniform in colour, keyed on the back and shall comply with DIN 18155. The ties shall be of a suitable type, size, colour and acid resistance.

Ceramic floor tiles shall be oil and acid resistant, true to shape, flat, free from flaws, cracks and crazing, uniform in colour and of an approved type, make and colour. Dimensions and tolerances shall comply with DIN 18158 and DIN 18166.

Cement based adhesives shall comply with the requirements of DIN 18156. Other adhesives shall be subject to the approval of the Engineer and mixed and used strictly in accordance to the manufacturer's printed instruction. Mortar materials and adhesives shall not alter the top surface of the tiles.

7.6.6.3 Preparation of Surfaces

Surfaces shall be prepared before covering with tiles in strict accordance with the manufacturer's instructions.

7.6.6.4 Placing of Tiles

Tiles, which are to be laid in cement mortar, shall be soaked in clean water for 15-30 minutes before fixing and allowed to drain for 10-15 minutes. Any surplus water shall be removed from the backs before laying. Tiles to be fixed with adhesives shall not be soaked or wetted before laying. All cutting to tiles shall be fair cutting using a tile cutter.

In interior finishing works all tiles, flags or mosaic shall only be set and laid before the fixing of windows and door frames and trims, and after stop rails, plumbing installations and the application of plaster. All tiles, flags and mosaic shall be set or laid plumb, in true alignment and horizontal or at the slope specified, without any projections, with regard to any specified reference or level lines. In wall coverings, projections shall be allowed only to the extent imposed by the particular type of tile or flag specified.

7.6.6.5 Fixing and Bedding

Thin tiles shall be generally adhesive fixed. Backgrounds shall be cleaned and primed according to the manufacturer's instructions and the adhesive shall be applied by the notched trowel technique and trowelled over the area to receive tiles in 4 mm thickness. Tiles shall be pressed in as recommended by the manufacturer. Thick tiles shall be generally bedded in cement-sand mortar, at least 10 mm thick. Any surplus mortar, which adheres to the face of the tile, shall be wiped off with a damp cloth before it sets hard.

The external angles and side and top edges shall be formed with rounded edge tiles. At intersections, returned rounded edge tiles shall be used.

7.6.7 Roofing

7.6.7.1 General

The work shall consist of supplying, laying and finishing complete insulation and roof coverings and shall include the provision of all necessary skirtings, copings, flashings etc. On completion, all roofs shall be left sound and watertight and in neat and clean condition. All roof finishes shall be carefully worked or fitted around pipes and openings.

Roofing systems shall be in general the "inverted roof" or "protected membrane roof system" where the waterproof membrane is laid directly onto the structural slab and the insulating layer is then laid on the membrane and protected by a layer of files. Any special working details prepared by the Contractor must be submitted to the Engineer for approval.

7.6.7.2 Waterproofing and Insulation

The structural slab or surface screed on it shall be primed before application of the membrane in accordance to the manufacturer's instructions. The insulation layer shall have a minimum density of 35 kg/m^2.

7.6.7.3 Covers, Flashings and Rainwater Outlets

Precast cement roofing tiles shall be formed with a minimum 10 mm facing of one-part white cement and three parts of sand, set on a backing of sulphate resistant cement mortar with a minimum cement content of 300 kg/m³.

Flashings shall be formed out of 0.8 mm aluminium with natural mill finish. Accessories such as hooks, nails, screws and clamps shall be of the same material and alloy.

Screeds shall be prepared of cement, sand and water in accordance to the requirements stipulated for screeds.

Rainwater outlets shall be a proprietary type approved by the Engineer. Outlets shall drain from the top interface between the waterproof membrane.

7.6.7.4 Workmanship

Workmanship shall be carried out in accordance with DIN 18338. The roof surfaces shall be uniform, compact and free from debris.

Waterproof membranes shall be 1.5 mm thick self-adhesive rubber bitumen applied strictly in accordance to the manufacturer's instructions. The membrane shall be continuous and take up abutments and pipes to above the insulation layer. Exposed membrane shall be solar protected. The waterproof membrane shall be dressed and bonded into rainwater outlets and under flashings.

The insulation board shall be not less than 50 mm thick closed cell extruded polystyrene loose laid in a single layer with tight staggered butt joints in accordance with the manufacturer's instructions. The board shall be trimmed to fit any fillets used under the waterproof membrane.

Flashings shall be sheet aluminium neatly cut to the width and length required. The aluminium shall be carefully bent using a slightly rounded former so as to avoid surface cracking. Where surface fixing is required, the sheet shall be pre-drilled and fixed with in oxidisable screws to proprietary fixings or hardwood grounds let into the surface of the base concrete or brick work.

Lightweight screeds shall be laid in accordance with the manufacturer's instructions and to falls not less than 1:40 with a thickness of 100 mm.

The screed shall be laid in two courses and in bays not exceeding 15 m², laid alternatively and finished with a mortar topping of 1:4 cement/sand mortar. Immediately after laying, the screed shall be protected from wind and sunlight and cured for 7 days.

7.6.8 Timber Works

7.6.8.1 General

A high standard of workmanship and materials shall be achieved in the works. The completed timber work shall be durable, well finished and designed and constructed to arrive at a service lifespan of at least 40 years.

Workmen employed in the manufacture and installation of timberwork shall be experienced carpenters.

7.6.8.2 Materials

Timber shall be of best quality, sound, in good condition, reasonably free from shakes and free from loose dead knots, insect attack, decay, twisting and warping. Timber shall be properly seasoned to suit the purpose for which it is intended. Only knots with characteristics similar to those detailed in DIN 4074 will be allowed. Where timber is prescribed as "selected" it shall be free from knots.

Softwood shall be either redwood, specially selected from the best unsorted and joinery quality or Douglas fir of selected merchantable quality or better.

Hardwood shall be selected and of best quality; pinhole borers shall particularly check it for infestation. Selected hardwood shall comply with DIN 4074, grade IA.

All plywood, chipboard or materials incorporating chipboard shall not be used in the works, except with express permission by the Engineer in writing.

7.6.8.3 Samples

Before commencing work, the Contractor shall submit samples of all types of timber to be used in the works for the approval of the Engineer. Timber, or carpentry and joinery units of which the material on delivery to the Site does not conform to the standard of approved samples will be rejected and replaced by the Contractor at his own expense.

7.6.8.4 Ironmongery

The Contractor shall provide all necessary ironmongery including matching screws, bolts, plugs and other fixings. The use of nails for ironmongery fixing will not be permitted.

Ironmongery shall be of the best quality and subject to the approval of the Engineer. Unless otherwise specified, ironmongery shall be of solid brass.

7.6.8.5 Fabrication

The carpenter shall perform all necessary morticing, tenoning, grooving, matching, housing, rebating and all other works for correct jointing. He shall also provide all metal plates, screws and other fixings that may be specified or necessary for the proper execution of the works and he shall carry out all works necessary for the proper construction of all framings, linings etc. and for their support and fixing in the works.

No nails shall be used to assemble or fix hardwood, major supports or ironmongery. Screws used in exposed locations and/or for hardwood shall be brass and complete with brass surrounds.

7.6.8.6 Timber Components

Flush doors shall have a minimum thickness of 40 mm and shall be faced both sides with hardwood veneered faces. The core of solid core flush doors shall be constructed of longitudinal laminations of precision planed timber, butt jointed and glued with resin-based adhesive under hydraulic pressure. All edges shall be bevelled and lipid with hardwood tongued into the edge of the door.

Hardwood doors shall be constructed out of teak or similar approved hardwood, with 100x38 mm stiles, 125x38 mm top rails and 225x38 mm middle and bottom rails. Where required, the doors shall be glazed with 6 mm wire polished plate glass, fixed with hardwood glazing beads.

Frames, architrave's and extension pieces shall be manufactured from red or whitewood timber and shall include the use of finger-jointed material. If exposed in the laboratory, the frames must be in hardwood.

7.6.9 Metal Windows and Doors

7.6.9.1 Metal Windows, Louvres and Doors

Metal windows and doors shall be handled with care and until fixed shall be stacked on edge on clean surfaces.

In brick openings, frames shall be fitted with fixing lugs in adequate number, and bedded in mortar.

In concrete openings, frames shall be plugged to the walls using zinc-coated screws.

To avoid corrosion of aluminium alloy frames, screws and other metal fixing in contact with them shall be of Aluminium, zinc or cadmium plated. In no circumstances shall copper fixings be used.

Frames shall not be used as centring for brickwork or to support a lintel.

Frames shall be carefully pointed in 1: 3 cement mortar and, after raking out the gap, shall be pointed with mastic.

7.6.9.2 Kind of Windows and Doors

When not otherwise specified, the Contractor shall use surface treated anodised aluminium windows and doors which shall be robust and of good quality.

Extruded aluminium members shall be fabricated conforming to DIN 1784.

Where members are formed from sheet materials, they shall be fabricated conforming to DIN 1783.

The main elements of the Aluminium solid section outer frame shall be at minimum tolerance not less than 2.0 mm thick. The thickness of all other structural elements of the sections shall be at minimum tolerance not less than 1.2 mm except for weather-stripping retaining flanges and glazing beads, which may be thinner.

All aluminium alloy parts shall be finished satin matt and anodised in accordance with DIN 4113.

Weather-stripping shall:

- be made from materials known to be compatible with aluminium;
- not shrink or warp or adhere to sliding surfaces or closing surfaces;
- not promote corrosion when in contact with the aluminium alloy used; and,
- be resistant to deterioration by weathering.

Joints in frames shall be made neatly and accurately either by welding or by mechanical means (e.g., cleating and screwing) and may have flush, stepped or lapped surfaces. Welded joints shall be cleaned off smooth on the surfaces, which are exposed when the window or door is in the closed position or where they come into contact with glazing.

Hinges and pivots shall be either of suitable corrosion-resistant materials or, if not compatible with aluminium, shall be separated from the aluminium by materials, which are compatible with it. Hardware, including fixings, shall be of suitable corrosion resistant materials. Materials or finishes, which are not compatible with aluminium, shall not be used unless they are satisfactorily separated from the Aluminium by materials, which are compatible with it.

Glazing beds, gaskets, glass adaptors and glazing compound shall be of materials compatible with aluminium and finishes thereon.

Windows and doors shall be such that glazing and reglazing on site is possible without the need to remove the outer frames from the structure of the building.

Mosquito screens shall be fitted to all windows and external doors.

7.6.10 Finish Hardware

7.6.10.1 General

The Contractor shall furnish and install all finish hardware to complete the work as specified.

The Contractor shall submit samples of all hardware to the Engineer for approval.

All hardware shall have the required screws, bolts and fastenings necessary for proper installation, wrapped in paper and packed in the same package as the hardware. Each package shall be legibly labelled, indicating that portion of the work for which it is intended.

All hardware shall be of the best grade, entirely free from imperfections in manufacture and finish.

Quantities, weight and sizes specified herein are the minimum that will be acceptable.
Finish of all hardware shall be dull stainless steel unless otherwise noted.

7.6.10.2 Hardware Description

Locks, Kind of lock for:

Entry, exit & office doors: keyed on side, button opposite side
Passage doors: knobs both sides, no lock
Storage room: single knob with key

Lock quality:
Tabular cylinder locks: stainless finish
Toilets: stainless outside, chrome inside, pin opening outside for emergency with button inside

Door closers: heavy duty type with stainless cover; top installation for either right or left hands operation
Stops: floor or wall mounted type, stainless
Door pull: 10 x 30 cm stainless plate, with 15 cm shaped pull securely fastened to plate; mounted with oval head stainless screws.
Kick plates: 20 cm stainless plate, width of door less 5 cm
Coat hangers: stainless steel, standard
Door hinges: 10 x 10 cm stainless steel, three per door
Flush bolts: 15 cm stainless
Gravity hinges: set of upper and lower, chrome finish, adjustable to stay slightly ajar
Cabinet hinges: 6 x 10 cm stainless, three per door
Friction catches**:** heavy duty - two parts with rubber grips concealed installation
Cabinet, drawer pulls: stainless steel, 10 cm grip with concealed bolt fastenings

7.6.10.3 Window hardware

Windows indicated to be pivot type shall be furnished with a pair of window fittings (friction stays), a window pull and one barrel bolt lock. Window fittings shall be galvanised or stainless steel. Window pull shall be 2.5 x 10 cm with 4 screws and barrel bolts 10 cm long, 6 mm bolt.

7.6.10.4 Installation of doors and hardware

Unless otherwise indicated, all hardware installation and hanging shall be done at the site.

Exteriors doors and doors in air conditioned areas shall be weather-stripped.

Provide one (1) painted wood key case in each structure, size 25 x 50 cm with door and lock. Supply plywood back inside with hooks for spare keys. All keys shall be clearly labelled with metal or hardboard tags size approximately 50 x 20 securely fixed to the keys and handed over to the Engineer.

Upon completion of the hardware installation, all items shall be inspected for proper operation. All work shall be protected and any damage or incorrectness shall be repaired.

Hardware shall not be fitted until the latest time in the Contract.

7.6.11 Glazing

7.6.11.1 General

The Contractor shall supply the glass required in those items of plant, furnishings and figments included in the Contract. Glass shall be of quality in accordance to DIN 1249 or equivalent.

Sheets shall be selected quality glazing and have approved weight. Labels showing the glass manufacturer name, type of glass thickness and quality will be required on each piece of glass and shall remain on the glass until it has been set and inspected.

7.6.11.2 Materials

Clear float glass shall be 6 mm thick. Obscured glass shall be rough cast to an approved pattern, untainted and of 6 mm nominal thickness. Wired glass shall be transparent with a polished surface, 6 mm thick, selected and cut parallel to the reinforcement.

Putty for glazing to timber frames shall be in accordance to DIN 18540, and to metal frames, it shall be of approved manufacture.

7.6.11.3 Size, Delivery and Storage

Dimensions of glass and frame shall provide minimum clearance equal to glass thickness for single glass on all four sides. The sealed space between face of glass and applied glazing stops shall be not less than 3 mm minimum.

Glass shall be delivered to the site in suitable containers allowing to protect the glass from weather and breakage.

7.6.11.4 Installation

Clear glass shall be used except where ordered otherwise. The glass shall be cut and installed without any visible lines or waves running horizontally.

Glazing in wood shall have rebates and beds primed and painted. The glass shall be firmly seated into the previously bedded and back-bedded rebate with glazing compound and secured in place with wood beds, attached with not less than 25 mm finish nails or flat headed screws, countersunk and set approximately at 15 cm centres. Nails and screws used in beds shall be corrosion resistant.

7.6.11.5 Cleaning up

All glass shall be cleaned at the completion of construction and any broken glass replaced. The glazing shall be maintained in a clean condition until the date of handing over the works.

7.6.12 Plumbing

7.6.12.1 Connections to Equipment and Fixtures

The Contractor shall provide all equipment and necessary material and labour to fixtures connect to the plumbing system all fixtures and equipment having plumbing connections, which are specified elsewhere.

All connections to the sanitary drainage system shall be trapped.

The supply line to each item of equipment or fixture shall be equipped with a cut-off valve to enable isolation of the item for repair and maintenance without interfering with operation of other equipment or fixtures.

7.6.12.2 Cutting and Repairing

The work shall be carefully laid out in advance, and no excessive cutting of construction will be permitted.

Damage to buildings, piping, wiring, equipment or appurtenances as a result of cutting for persons skilled in the trade shall repair installation involved.

7.6.12.3 Protection to Fixtures and Equipment

Pipe openings shall be closed with fixtures and caps or plugs during installation.

Fixtures and equipment shall be tightly covered and protected against dirt, water and chemical or mechanical injury.

Upon completion of all work, the fixtures, materials and equipment shall be thoroughly cleaned, adjusted, and operated.

Belts, pulleys, chains, gears, couplings, protecting setscrews, keys and other rotating parts shall be located so that any person in close proximity thereto shall be fully enclosed or properly guarded.

7.6.12.4 Sanitary, Wastewater and Vent Piping, General

Pipe materials shall conform to the following requirements:

PVC Pipe and fittings shall be spigot-and-socket type of solvent weld joints.
Ductile Iron Pipe shall be acc. to EN 877

7.6.12.5 Sanitary, Wastewater and Vent Piping Installations

Horizontal waste and drain pipes shall have a minimum slope of 10 mm per meter. Vent pipes in roof spaces shall be run as close as possible to the underside of the roof without forming traps in pipes, using fittings as required. Vent and branch-vent pipes shall be so sloped and connected as to drip back to the vertical stack by gravity.

Changes in pipe size on sanitary and waste water drain lines shall be made with reducing fittings. Use of bushings will not be permitted.

Changes in direction shall be made by the appropriate use of 45° Y-branches, long or short-sweep 90°, 45°, 22½°, or 11¼, or by a combination of these or equivalent fittings.

Sanitary tees and 90°-bends or elbows may be used in drainage lines only where the direction of flow is from horizontal to vertical, except elbows may be used where the change in direction of f low is either from horizontal to vertical or from vertical to horizontal, and may be used for making necessary offsets in vertical lines.

Slip joints will be permitted only in trap seals or on the inlet side of the traps.

Installation of pipes and fittings shall be carried out in accordance with the manufacturer's recommendations. Mitring of joints for elbows and notching of straight runs of pipe for tees will not be permitted.

Threaded joints shall have ISO/R7 pipe threads with graphite or inert filler and oil, with an approved graphite compound or with polytetrafluoroethylene tape applied to the male threads only.

7.6.12.6 Buried Drainage Pipes

Underground drainage pipes between buildings and manholes of drainage systems shall be 150 mm diameter of the material specified above.

When passing under buildings, paths, roadways, etc., 1 drainage piping shall be laid accurately to falls on a bed of class C 8/10 concrete, 15 cm thick and 30 cm wide and after laying shall be entirely encased in class C 8/10 concrete.

Piping outside building shall be laid on a bed of class C 8/10 concrete 15 cm thick and 30 cm wide and shall be hunched up on- both sides with class C 8/10 concrete.

Piping fixed vertically is to be well secured to walls, etc., with approved metal holder bats at every joint, built into walls as directed.

Rodding and inspection eyes are to be provided at all ends and junctions for cleaning purposes.

The Contractor shall give notice in writing when drainage trenches have been excavated to their full depths and trenches shall be inspected and approved by the Engineer before concrete beds are laid.

The Contractor shall give further notice in writing when concrete beds have been laid and these must also be inspected and approved by the Engineer. No drainage trenches shall be filled or drains covered up until they have been inspected, properly tested, and finally approved by the Engineer, or until the dimensions of trenches, etc., have been checked and agreed upon by the Contractor and the Engineer.

7.6.12.7 Flashing

Pipes passing through roofs shall be flashed using lead or copper flashing with an adjustable integral flange of adequate size to extend not less than 200 mm from the pipe in all directions and flashed into the roofing to provide a watertight seal. Sanitary vent stacks through corrugated asbestos roofing shall be installed to be watertight to the details shown, with a PVC reducing socket, copper flashing and cement mortar.

7.6.12.8 Traps

Each fixture and piece of equipment having an integral trap or seal, requiring connections to the sanitary drainage system shall be equipped with a trap. Each trap shall be placed as near the fixture as possible, and no fixture shall be double trapped. Traps installed on PVC pipe shall be

PVC. Traps installed on lavatory wastes shall be brass recess-drainage pattern, or brass-tube type, chrome plated.

7.6.12.9 Floor Drains

Floor drains shall have cast iron bodies with double drainage flange, weep holes and bottom outlet. Outlet shall be inside caulked or screwed.

Shower and toilet room drains shall have adjustable chrome plated brass strainers with free strainer area not less than one- and one-half times the connecting pipe size.

Pump room, equipment room and area drains shall have anti-tilting slotted cast iron grates of not less than 150 mm diameter.

7.6.12.10 Downspouts and Clutters

Downspouts for roof drainage shall have a diameter not less than 100 mm and shall be fabricated of light gouge galvanised steel or PVC. All offsets and bends shall be made with 451-bends and no skewed joints or bowed down spouts will be permitted. Downspouts shall be supported with galvanised steel straps or PVC straps.

Gutters shall have half round or rectangular profiles in asbestos cement, PVC, or galvanised iron. The width or diameter of gutters shall be 150 mm.

7.6.12.11 Water Pipe, Fittings and Connections – Generally

Water pipe within structures shall be of copper and water piping in the ground shall be either of PE or PVC.

Fittings for copper tubing shall be flared brass or solder-type bronze or wrought copper. Fittings for brass pipe shall be brass. Fittings for PVC pipe shall be PVC socket type.

7.6.12.12 Water Pipe, Fittings and Connections

The piping shall be extended to all fixtures, outlets, and equipment. The water piping system shall be installed so as to be drained. Drainage shall be accomplished using 12 mm plugged or capped fittings at each low point, except where a drain valve or a hose tap is reasonable.

Pipe shall be cut accurately to measurements established at the building by the Contractor and shall be worked into place without springing or forcing. Changes in pipe sizes shall be made with fittings. Use of bushings will not be permitted. Change in direction shall be made with fittings

Care shall be taken not to weaken structural portions of the building.

Exposed piping shall be run parallel with the lines of the building, unless otherwise indicated.

Branch pipes from service lines may be taken from top, bottom, or side of the main, using such crossover fittings as may be required by structural or installation conditions.

Pipes, valves and fittings shall be kept in a sufficient distance from other work and other pipes to permit not less than 25 mm between pipes and other work. No water pipe shall be buried in floors or cast in concrete walls, unless specifically indicated or approved.

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Allowance shall be made throughout for expansion and contraction of pipe. Sufficient flexibility shall be provided on all branch runout from mains to provide for expansion and contraction of piping. Flexibility shall be provided by installing one or more turns in the line so that the piping will spring enough to allow for expansion without straining.

Joints in steel piping may be screwed or flanged. Installation of pipe and fittings shall be made in accordance with the manufacturer's recommendations. Mitring of joints for elbows and notching of straight runs of pipe for test will not be permitted. Threaded joints shall have ISO/R7 pipe threads with graphite or inert filler and oil, with an approved graphite compound, or with polytetra fluoroethylene tape applied to the male threads only. Unions shall be provided where required for disconnection.

7.6.12.13 Valves

Valves shall be provided for piping to equipment and fixtures. No valve shall be installed on any line with its stem below the horizontal. All valves shall be gate valves, unless otherwise specified or indicated.

7.6.12.14 Unions

Unions shall be installed in easily accessible locations. Gaskets for flanged unions shall be of the best quality fibre, plastic or leather. Unions shall not be concealed in walls, ceilings, or partitions.

7.6.12.15 Hose Taps

Hose taps shall be brass with 13 mm inlet threads, hexagon shoulder, and 20 mm hose connection, unless otherwise indicated.

Hose taps installed on exterior walls of buildings shall have an integral wall flange which shall be securely anchored to the wall to prevent any strain on the supply pipe when attaching or disconnecting hose.

Anchors shall use brass or bronze bolts or screws with expansion shields in the concrete or masonry wall.

7.6.12.16 Pipe Sleeves

Pipe passing through concrete or masonry walls or concrete floors shall be provided with pipe sleeves fitted into place at the time of construction. Sleeves shall be steel pipes.

Each sleeve shall extend through its respective wall, floor or roof, and shall be cut flush, except sleeves in toilet room floors shall extend 25 mm above the finished floor.

Unless otherwise indicated, sleeves shall be of such size as to provide a minimum of 6 mm all around clearance between bare pipe and sleeves.

The annular space between pipe and sleeve shall be packed and caulked watertight.

7.6.12.17 Pipe Hangers Insert and Supports

The location of hangers and supports shall be coordinated with the structural work to assure that the structural members will support the intended load.

7.6.12.18 Fixture Support

Wall-hung fixtures shall be fastened to the wall by 9.5 mm through bolts where appearance of the bolts is not objectionable. Exposed bolt heads in finished areas shall be hexagonal and painted. Exposed nuts shall be chromium-plated hexagonal cap nuts. Washers shall be painted or chromium-plated to match bolt heads or nuts.

For solid masonry and where through bolting is objectionable, fixtures shall be fastened with 9.5 mm machine bolt expansion shields or 9.5 mm stud-type expansion bolts.

For cellular-masonry construction, where through bolting is objectionable, fixtures shall be fastened with 9.5 mm toggle bolts. Toggle bolts shall extend into the cell of the masonry unit and shall be of the gravity or spring-wing type. Lavatories mounted on pipe chases shall be installed with one or two steel backup plates as required. The backup plates shall be 3.2 mm thick, 100 mm wide and not less than the width of the fixture.

Urinals mounted on pipe chases shall be installed with one or two steel backup plates as required, as specified for lavatories. Backup plates shall be suspended on the inner side of the chase by two 3.2 mm thick metal clips placed in the mortar joint. The metal clips and through bolts shall be tack-welded to each plate. The plates shall be installed horizontally and fastened to the top and bottom of the lavatory or urinal as required.

7.6.12.19 Type of Fixtures, General

Material specified herein shall be the product of manufacturers regularly engaged in the manufacture of such products.

Generally, all fixtures, except water closets and urinals, shall have the water supply above the rim. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers. Angle stops, straight stops, stops integral with the taps, or concealed type of lock-shield, and loose-key pattern stops for supplies shall be furnished and installed with fixtures.

Where space conditions will not permit standard fittings in conjunction with the cast iron floor flange, special short-radius fittings shall be provided. Connections between earthenware fixtures and sanitary pipe shall be made absolutely gastight and watertight with a closet-setting compound or with a neoprene gasket and seal.

Use of natural-rubber gaskets or putty will not be permitted for these connections.

Bolts shall be not less than 6.4 mm in diameter and shall be equipped with chromium-plated nuts and washers. Fixtures with outlet flanges shall be set the proper distance from floor or wall to make a first-class joint with the closet-setting compound or gasket and fixture used.

7.6.12.20 Fixtures

The type of fitting to be used in each location shall be in accordance with the following schedule in which the sizes given for wastes taps outlets, etc., refer to the external diameter of the fitting:

Ball valves to cisterns of sanitary fittings shall be to DIN and of the low-pressure type.
Taps generally shall be chrome plated easy clean deck pattern bib taps to DIN. Taps shall be 15 mm in diameter and shall have capstan heads clearly marked as appropriate with red and blue spots signifying "hot" and "cold" respectively.

Shower fittings shall be breech pattern complete with exposed fixed chrome plated riser pipes matching clips swivel pattern shower rose and taps.

Wash down W.C. pans shall be white vitreous china to DIN 1387 with matching traps and black solid plastic ring seats and covers to DIN complete with chrome plated bar hinges and rubber buffers. Each flushing cistern shall be white vitreous china to DIN or plastic with a capacity of 9 litres and shall be provided with a side connection reversible plastic siphon and flush pipe. The cistern shall include a ball valve with rubber cone joint and a chrome plated flushing lever and shall be supported on white plastic-coated support brackets.

Eastern type WC's shall be white vitreous china suitable for sinking into floors and provided with raised foot treads and matching traps and vents. Each suite shall be supplied with a 9 litres white vitreous china or plastic side inlet flushing cistern on white plastic-coated support brackets. The cistern shall be complete with the following items: Plastic valveless siphons, Ball valve with rubber cone joint, Overflow, Chrome plated chain and plastic pull, 42 mm diameter stainless steel flush pipe and matching fixing clips.

Urinals shall be white vitreous china to DIN 1390 complete with division wall hangers and supports. An automatic flushing cistern of 14 litre capacity with siphon drip tap and wall hangers shall be provided. The flush pipe shall be in stainless steel complete with matching spreaders and clips together with 35 mm diameter outlet gratings and 35 mm diameter chrome plated traps.

Counter top lavatory basins shall be self-rinsing white vitreous china supported on white plastic-coated support brackets and complete with the following items: Overflow, Chrome plated chain and plug, 35 mm diameter chrome plated waste outlet, Hot and cold taps, 35 mm diameter chrome plated bottle trap.

Wall laboratory basins are to be white vitreous china to DIN 1386 with minimum dimensions of 550 x 400 mm. Each basin shall be complete with the following items: Skirting, Gap overflow, White plastic-coated support brackets, Hot and cold taps, 35 mm diameter chrome plated waste outlet; chrome plated chain and plug; 35 mm diameter chrome plated bottle trap.
White glazed fire clay sinks with dimensions 500 x 400 x 25 mm. Each sink shall be complete with the following items: Gap overflow, White plastic-coated support brackets, Wall mounted 15 mm diameter hot and cold bib taps, 42 mm diameter chrome plated waste outlet; chrome plated chain and plug; 42 mm chrome plated bottle traps.

Combined stainless steel sink drainer units shall be to the appropriate DIN standards. Each unit shall be 1,000 x 600 mm and be complete with the following items: 42 mm diameter combined overflow and waste fitting, chrome plated chain and plug; 15 mm diameter chrome plated sink

mixer taps with capstan heads clearly marked as appropriate with red and blue spots signifying "hot" and "cold" respectively; 42 mm diameter chrome plated bottle traps.

Shower trays shall be in white glazed fire-clay with minimum dimensions of 800 x 800 x 200 mm and with 42 mm diameter strainer waste complete with plug chrome plated chain and stay fixed to tiled wall and 42 mm diameter bottle trap.

Shower curtain rails shall be chrome plated 25 mm diameter tube with chrome plated and brackets plugged and screwed to walls. Shower curtains shall be in plain white plastic complete with eyelets and hooks.

Towel rails shall be chrome plated 25 mm diameter tube with chrome plated end brackets plugged and screwed to walls.

Toilet roll holders shall be chrome plated with roller holders of an approved pattern and shall be of the lockable type.

Mirrors shall be copper backed float glass mirrors 6 mm thick, pre-drilled and fixed with chrome plated dome headed screws. Distance washers shall be fixed with mirror fixing points. Water coolers shall be of an approved type and manufacture. They shall be free standing models of the electrically refrigerated type with a minimum cooling capacity of 30 1/h from 250°C inlet water to 100°C drinking water in a room temperature of 300°C. The cabinets are to be corrosion proof with the cabinet frame fasteners and bases in stainless steel.

The bubbler shall have a lever handle and built-in pressure regulator to deliver a smooth steady flow of water at supply pressures from 1.40 to 8.60 bars.

Waste outlet shall be 35 mm diameter and supply pipes shall be 15 mm diameter. The coolers shall be fitted with chrome plated swan necked glass fillers with push down valves.

Electric water heaters shall be of an approved pressure vessel type, comprising the electric heating element, adjustable Thermostat, control pumps, complete piping connection system with combined check/pressure relieve valve in the inlet side, necessary connection cable and protection switch with fuses. The storage capacity shall be not less than 120 litres.

7.6.12.21 Cleaning and Adjusting

Equipment, pipes, valves, fittings, fixtures and appurtenances shall be cleaned of grease, metal cuttings, and sludge that may have accumulated from operation of the system during the test. The Contractor shall repair any stoppage, discolouration or other damage to the finish, furnishings, or parts of the building, due to the Contractor’s failure to properly clean the piping system. Flush valves and automatic control devices shall be adjusted for proper operation.

7.6.12.22 Disinfection

After pressure tests have been made, the entire water system shall be thoroughly flushed with water until all dirt and mud have been removed before introducing chlorinating material. The chlorinating material shall be either chlorine solution or hypochlorite. The chlorinating material shall provide a dosage of not less than 50 parts per million and shall be introduced into the system in an approved manner. The treated water shall be retained in the pipe long enough to destroy all non-spore forming bacteria. Except where a shorter period is approved, the retention

time shall be at least 24 hours and shall produce not less than 10 ppm of chlorine at the extreme end of the system at the end of the retention period. All valves in the system being sterilised shall be opened and closed several times during the contact period. The system shall then be flushed with clean water until the residual chlorine is reduced to less than 1.0 ppm. During the flushing period all valves and taps shall be opened and closed several times.

From several points in the system the Engineer may take samples of water in properly sterilised containers for bacterial examination. Disinfection shall be repeated until tests indicate the absence of pollution for at least 2 full days. The system will not be accepted until satisfactory bacteriological results have been obtained.

7.6.13 Fire Protection

Portable fire extinguishers shall be installed in all buildings at strategic positions (stair cases, corridors) in a manner that traffic will not be obstructed. As a further condition, extinguishers shall be located at easily visible and accessible locations regarding the event of a fire.

Preferably dry chemical extinguishers, multipurpose type, shall be supplied. As a rule, powder units containing 12 kg shall be supplied, which combine all of the extinguishing effects, and are permitted for fires of class A to C in the presence of electrical voltage up to 1,000 V. For class D fires involving combustible metals dry compound extinguishers shall be introduced. The portable fire extinguishers shall be fitted with spring headed interchangeable safety valves.

Rooms and areas where voltages above 1,000 V are to be present, housing relays, control and computer units shall be equipped with portable carbon dioxide extinguishers in addition. Also, suitable masks to prevent any injury to personnel shall be supplied.

All extinguishers shall be designed for service over a period of 20 years taking the conditions at the site into account.

The extinguishers must be provided as early as possible, however, at latest on commencement of the commissioning preparations.

After completion of the installation, random tests of 5% of the portable extinguishers supplied shall be performed. The Contractor shall provide the necessary refills.

The following arrangement criteria shall be met:

Maximum walking distance to an extinguisher: 22 m
Maximum area to be protected per extinguisher: 500 m².

7.6.14 Corrosion Protection and Painting

7.6.14.1 General

This Specification covers the general requirements and standards of workmanship and the painting and protective coatings required to be carried out by the Contractor of the works, except where particularly redefined in individual specification clauses or as necessary due to a particularly corrosive local environment, the possible reaction of escaping chlorine on the works or on the structures or the reaction of chlorine residuals on phenolic paints (e.g. inside

pipelines), harmful or toxic paint in contact with process liquids, or other special requirements, in which case the Contractor submit his own special specification along with his tender.

No alternative or substitute painting standard or specification will be accepted unless it is specifically required for the above stated reason. No painting or protective coating will be accepted by the Engineer unless it is at least to the standard and of the quality specified herein.

7.6.14.2 Contractor's Responsibility

The Contractor shall be responsible for the complete cleaning, preparation, priming, painting and protection of the works carried out by him.

7.6.14.3 Appropriate Standards

Where no explicit instruction is given standards in the Specification or by the manufacturer concerning any particular aspect of the workmanship, materials or procedures in connection with anti-corrosion protective systems in the works for iron and steel structures, the relevant recommendations of the following standard or code of practice shall apply:

DIN 50900 Corrosion of metal
DIN 50928 Protective coating of iron and steel structures against corrosion
DIN 18364 Surface protection of steel structures
DIN 50976 Hot-dip galvanised coatings on iron and steel articles
DIN 8565 & DIN 8567 Sprayed metal coatings

All coatings shall be suitable for the long-term protection of the plant under operational conditions at the site of installation.

The Contractor's attention is specifically drawn to the extremes of temperature and humidity recorded in the region and he shall take into account possible abrasions, restricted ventilation, and the various potentially corrosive environments within the works buildings and structures.

7.6.14.4 Decorative Finish and Final Appearance

The Contractor is advised that internal civil works finishes, furnishings and decorative colour schemes in the main operational areas (e.g., upper filter gallery) shall be of a pleasing appearance, Co-ordinated and designed to produce a comfortable working environment. Accordingly, the Contractor shall allow for consultation with the Engineer regarding the final colour scheme and decoration of the works.

7.6.14.5 Trial Areas and Sample Pieces

Prior to the commencement of the site, painting work designated area(s) or section(s) of the works shall be completely painted as a sample of the work and workmanship to be carried out. The area(s) or section(s) shall include complete samples of all the major painting required in the works.

The area(s) shall be offered for review by the Engineer and shall, upon approval, be then preserved as a reference standard for the work.

No extra payment will be made for carrying out such protection or decoration in advance of the general work, or for the removal and repetition or improvement of the work if required by the Engineer in order to achieve the specified standard.

7.6.14.6 Precautions

All surface fittings, ironmongery, etc., except hinges shall be removed before painting and refixed on completion. They shall be entirely free of any droppings, paint smears and blemishes. Labels, pump and other machinery name plates, data plates, markings, etc., shall not be overpainted but carefully preserved by removal and replacement or by masking.

The Contractor shall pay particular attention to the toxicity, in flammability and the explosive dangers related to the storage and application of the systems and shall take all precautions necessary to the satisfaction of the Engineer to protect his operatives, the public and other site personnel.

No one site coat may proceed in any section of the works until the entire section is complete and the Engineer has had notice of completion in order that he may inspect the work and authorise the application of subsequent coats. Each successive coat shall preferably be of different colour or shade to facilitate inspection. The Engineer may apply his own identification markings on undercoats to ensure full compliance with the Specification.

Brushes, tools and equipment shall be kept in a neat and clean condition. Painting shall not be carried out in the vicinity of other operations, which might cause dust. The final coat shall be uniform in colour and free from brush marks, runs or other defects.

All paint shall be "new" and "fresh" and obtained from approved manufacturer(s).

If so directed by the Engineer, the Contractor shall ask the paint manufacturer(s) to spot-check the preparation and painting and submit to the Engineer and the Contractor a written report on his observations.

All paint shall be supplied in sealed containers bearing the following information in addition to any statutory requirements:

Manufacturer’s name, initials or trade mark;
Whether priming, undercoat or finishing coat;
Whether for interior or external use;
The colour reference number;
The method of application (e.g., brush);
The batch number and date of manufacture of re-test
The shelf life of the contents.

Containers for materials other than paints shall bear as much of the above information as appropriate.

Paint shall be supplied from the Contractor's paint store to the painters ready for application. Any addition of thinners shall be made in the store under supervision and up to the limit detailed on the appropriate manufacturer’s paint data sheet for the particular method and conditions of applications concerned.

Paint, thinners, etc., shall be stored in sealed containers in a lock-up store at a temperature of not less than 4°C and not more than 27°C. Any special storage conditions for the paint recommended by the manufacturer shall be observed.

7.6.14.7 Application of Protective Coating and Paint System

Unless specifically specified elsewhere, the protective systems shall be applied in accordance with the manufacturer's instructions to the full thickness range specified, particular note being taken of the requirements for the time interval between successive coats of the system.

The coating thickness for painting on concrete or plaster surfaces shall be in accordance with the manufacturer's instructions or proposals.

7.6.14.8 Paint Thickness and Continuity

The Contractor shall provide and maintain, during manufacture and on site, gauges and measuring equipment of an approved type to ensure that the specified film thickness are achieved, paint holidays are avoided, and adhesion is to the satisfaction of the Engineer.

Wet film thickness gauges shall be provided to and used by each painter to check the rate of paint application.

The thickness of the built-up dry film after each paint coat applied to steel or other magnetic surfaces shall be measured systematically with a dry film thickness gauge.

The Contractor shall adopt holiday detection on concrete, steel and iron surfaces and shall use a suitable method of detecting pinholes in the coating system after trials on test plates, which shall be notified in advance to the Engineer.

The sweep voltage on high voltage DC equipment shall not exceed half the voltage required to spark through the complete paint system specified.

Gauges, instruments and meters shall be maintained in an accurate working condition and shall be made available to the Engineer for checking when requested.

The following instruments, with the manufacturer's operating instructions, shall be provided, maintained and used by the Contractor's inspector. In addition, under the Contract a separate set shall be provided and maintained for the Engineer's sole use for the duration of the Contract:

1 adhesion tester, cover 0 to 280 kg/cm^2;
1 DC high voltage holiday detector, 20 kV, with rechargeable batteries;
1 paint inspection gauge, 0 to 500 microns;
"wet-check" moisture meters with suitable concrete and timber scales;
1 dry film thickness gauge, 0 to 500 microns;
wet film gauges, up to 500 microns;
1 steel temperature gauge, up to 50°C;
1 air humidity gauge;
1 air Thermometer (maximum and minimum);
surface profile gauge, up to 150 microns.

Daily checks shall be carried out and recorded on site in accordance with the provisions of DIN 55928.

7.6.14.9 Dry Film Thickness

References in the Specification to dry film thickness (DFT) shall mean the minimum dry film thickness measured with a suitable instrument, either of individual coats, or the total system, as specified in microns (um). The maximum permissible coat tolerance shall be + 15%, - 0% over the DFT.

7.6.14.10 Colour Coding

Pipework, tanks and ducting shall be colour coded by totally painting with the appropriate code colour as specified.

The principal code colours shall be as stipulated under 8.1.10.
The definition RAL-notation of the colours mentioned above shall be subject to Engineer's approval after the commencement of the works.

The colour coding for other minor pipelines, etc., will be notified to the Contractor prior to the commencement of erection.

All pipes and tanks shall also bear painted labels to indicate the contents. Lettering shall be in Spanish. Labels on pipework shall incorporate arrows showing the direction of flow.

7.6.14.11 Knotting and Stopping

Knotting shall comply with DIN 4062.

Stopping for concrete or sand/cement plastering shall be of similar material to the background and shall have a similar surface finish.

Stopping for woodwork, hardboard and plywood shall be a proprietary spirit-based wood filler, tinted to match the woodwork.

Parts to be subjected to manufacturer's shop testing shall not be stopped or surface treated prior to satisfactory completion of the testing. Thereafter the specified treatment shall be applied.

7.6.14.12 Systems to be Compatible and Complete

All coatings, stoppings, primers, compatible and undercoats and finishing paints of any one complete protective system shall be compatible with each other and the completed system shall provide continuous, pore-free coatings resistant to physical and chemical disintegration in the environment in which they are to be used.

As far as is practicable, materials, forming any one protective and/or decorative system used in the permanent works, shall be obtained from one manufacturer.

7.6.14.13 Bitumen Coating

Bitumen coatings shall be to DIN 18195, 18336 and DIN 18337.

Suitable grades shall be selected where the coating will be in contact with potable water.

7.6.14.14 Waste

The Contractor shall provide onsite suitable moveable receptacles into which are to be placed all the liquid, slops, washings, etc. All solid refuse or inflammable residues shall be removed from site or carefully burned. No refuse shall be deposited on any soil or disposed down any permanent sanitary fittings, sinks or drains. The Contractor shall immediately clean up any unauthorised deposition and remove from the site any employee found to be responsible.

7.6.14.15 Application

7.6.14.15.1 Spray application

The equipment to be used for spray application shall be in strict accordance with the paint manufacturer's instructions for each coating material. Any runs shall be immediately brushed out.

7.6.14.15.2 Brush Application

The shape and quality of the brushes shall be suitable for the work to be carried out. Extension handles to brushes shall not be permitted.

7.6.14.16 Primers

Except if otherwise specified, primers for steelwork shall comply with the relevant DIN standards and contain corrosion-inhibiting pigments, adhere firmly to the substrate and form suitable bases for the subsequent coats.

7.6.14.17 Surface Preparation by Sand Blasting

All surfaces to be coated shall be free of scale, rust, grease, oil, dust and other deleterious materials.

The surface finish of sand blasted steel shall be in accordance with the relevant DIN standard and to a visual standard in accordance with SIS 05 59 00 at the time of painting. The blast profile shall be within the limits 50 - 75 microns.

Abrasives shall be restricted to reusable iron or steel (grit and shot) or copper slag. The type and grades of abrasive shall be selected in accordance with the appropriate DIN standard.

Within four hours of completion of surface preparation, and before surface re-rusting occurs, a coating of primer shall be applied to avoid deterioration of the prepared base metal. No contamination shall be permitted to occur between blast cleaning and primer coating.

7.6.14.18 Metal Coatings, general

Metal coatings required for protective purposes on any item of metalwork shall be applied as shop coats after fabrication of the items is completed, including all punching, welding, drilling,

grinding, screw tapping and cutting, and after the removal of surface defects. Tapped holes shall be blanked off before the metal coating is applied.

Except if specified otherwise, all steelwork shall be galvanised either by hot dip or by zinc spray both not less than 100g/m^2.

7.6.14.19 Coatings of steel structures, general application

Coatings of general steel structures shall be multi-layered and as follows:

Sand blasting to SA 2 ½ acc. to EN ISO 12944 part 4 and free of dirt, oil, grease
1 shop coat of 1-component high-pigmented rich zinc polyurethane primer, of low solvent content, 80micron as primer, (Friazinc PUR or equivalent)
field coat of 1-component high-pigmented mica-filled polyurethane paint, of low solvent content, 80micron, (Icosit PUR or equivalent)
1 finish coat of 2-component epoxy resin, low solvent content, 80 microns (Icosit EG 4 of micaceous iron colour or equivalent)

7.6.14.20 Coatings of steel pipes and tanks for water

Coatings inside and outside on steel tanks and their pipework shall be multi-layered and as follows:

Sand blasting to SA 2 ½ acc. to EN ISO 12944 part 4 and free of dirt, oil, grease
1 shop coat of 2-component high-pigmented rich zinc epoxy primer of low solvent content, 20micron as primer, weldable (Friazinc R or equivalent)
1 site coat of the same primer, 60-micron, spray application (Friazinc R or equivalent)
2 finish coats of solvent-free 2-component epoxy resin, 225 micron each (Icosit TW1 or equivalent)

7.6.14.21 Dehumidification Required for Special Purposes

The Contractor shall supply and operate such dehumidification equipment as may be necessary to preserve blast cleaned surfaces in a pristine condition until they can be coated and/or to provide the curing conditions necessary for such coats.

7.6.14.22 Classification of Painting

Lettered classification of surfaces shall be used for the purpose of identifying the protective coating specified herein:

"A": Surfaces above process liquid level and not liable to splashing thereby, in non-aggressive atmosphere.
"B": Surfaces in contact with untreated or treated water for potable use.
"C": Surfaces below process liquid level or liable to splashing thereby in non-aggressive solutions and/or atmospheres.

For the Contractor’s convenience the painting requirements are summarised in the table at the end of this section.

7.6.14.23 Embedded Steel

Steel which is to be totally embedded in concrete shall be cleaned to Swedish Standard St2 and shall not be primed.

7.6.14.24 Plain Surfaces

The only surfaces of iron or steelwork or non-corrosion resistant materials, which are to be left, unprotected by paint or metals coating are:

The internal surfaces of boxes or hollow sections which are of dimensions too small to permit access for painting either at the fabrication stage or for maintenance during the operation life of the steelwork and which are to be hermetically sealed by welding;

Those surfaces of built-in iron or steel members which are to have concrete cast against them;
Machine plain parts and bearing surfaces which shall be thoroughly cleaned, polished and protected from corrosion by painting with one coat of a mixture of white lead and tallow or other similar approved material before dispatch. The Contractor shall provide solvent for removing the treatment;
Parts which are specified to include corrosion allowances instead of protective coatings.

Surfaces of iron or steel members, which are to have concrete cast against them, shall be clean and free of deleterious matter and loose rust at the time of concreting.

The paint protection system, to be applied to the permanently exposed faces of these members before the members are built in, shall be continued for 50 mm as marginal strip along the contact surface.

No paint containing Aluminium in metallic form shall have direct contact with concrete.

7.6.14.25 Repair of Defective Work

Unless specified elsewhere, areas of paint on steelwork, which have been damaged, shall be cleaned to sound material and the edges of the undamaged paint smoothed with sand-paper to a gentle bevel. Thereafter, the specified paint system shall be applied in accordance with manufacturer's instructions to bring the damaged area up to the same state of protection as the surrounding paintwork, with each coat of new paint overlapping the corresponding existing coat of paint by at last 50 mm.
Where epoxy coatings are damaged, suitable repair supplied by the manufacturer of the original coating shall be applied in accordance with the manufacturer's instructions.

7.6.14.26 Fastenings

Bolts, nuts and washers and other demountable fastenings of all galvanised parts and also aluminium alloy parts shall be in stainless steel to the appropriate DIN standard and shall remain unpainted. P.T.F.E. washers shall be fitted beneath bolt-head and washer when fastening galvanised and aluminium alloy parts.

Fastenings, except high tensile, of all ferrous parts shall be steel prepared and galvanised to or sherardised to the relevant DIN standards, primed and painted in accordance with location.

Unless specifically approved and required for superior protection, electro-galvanising, nickel, cadmium or any other plating process, except chromium plating, will not be acceptable, and shall not be offered.

7.6.14.27 Painting and Protection of Bolted Connections

Joint areas of bolted connections shall be masked to maintain the surfaces free from any paint applied prior to making the connections. Masking shall be removed before erection.

After installation and after all bolts have been tightened, the area of the connection shall be cleaned to remove all dirt, dust, oil or other contaminant. Particular care shall be taken to ensure that all traces of oil and grease are removed from bolts, nuts and washers.

Bolts, nuts and washers and any exposed at bolted connections shall also be primed as specified, particular care being taken to ensure that any crevices are fully sealed.

The remaining coats of the paint system shall then be applied.

Following painting and where the bolted connections are in an area to be backfilled (pipe trench flanges, etc.) the bolts, nuts and washers and the entire joint assembly shall be carefully packed with an approved purpose made water proof protective paste (non solvent) and finally wrapped with an approved protective paste impregnated tape to completely encase the assembly. Pipe joint protection shall continue along the length of the barrel for a distance of 200 mm.

7.6.14.28 Copper and Brass

Copper pipes and brass fittings shall be painted where they are located in aggressive locations, or to colour code the function.

7.6.14.29 Plaster and Concrete Protection

Where specified or required for the protection of the work or the containment or storage of chemical solutions, concrete or rendered surfaces shall be protected with paint systems accordingly to the table at the end of this section.

7.6.14.30 Preparation of Concrete and Rendered Surfaces

Concrete and rendered surfaces shall be thoroughly cured in accordance to the manufacturer’s instructions before the application of any painting system is begun.

7.6.14.31 Minimum Thickness and Adhesion Tests for Painting Systems, Concrete and Plaster

The total dry film thickness of any used paint system shall have a minimum value of tests for 0.75 mm. In order to restore the coating integrity and plaster thickness whenever the paint inspection gauge is used or wherever the coating has been otherwise damaged, the surface shall be abraded for 50 mm around such damage and the area touched in with not less than two thick applications.

7.6.14.32 Preparation of Plaster, Brickwork and Concrete Surfaces

Efflorescence present on the surface of internal plaster, brickwork and concrete shall be removed by scraping and brushing before any surface paint is applied. When fluorescence has been removed surfaces shall be left for at least three days before priming. Painting shall be deferred where further salt deposits form on the surface during this period.

Plaster surfaces to be painted shall be cleaned down, smoothed as necessary, and all cracks shall be filled with stopping for plaster. All fittings shall be carried out before paint is applied to the surface.

Brickwork, blockwork and concrete surfaces shall be cleaned of all contaminating matter before being primed. Subject to the approval of the Engineer large holes which would cause a break in the paint film shall be filled with mortar, the surface being rubbed down to match the surrounding areas.

7.6.14.33 Preparation of Wood Surfaces

Wood surfaces shall not be painted when the moisture content of the timber measured with an electric moisture meter exceeds 12% for interior surfaces and 18% for exterior surfaces.
Hardwoods and soft woods for which a clear finish is specified shall be rubbed down with abrasive paper to give a smooth surface, which shall be free from contaminating substances, scratches and other imperfections.

Prior to coating all nail and screw holes, etc., shall first be stopped.

Surfaces, which are to be painted, shall be rubbed down to remove all contaminating substances and imperfections, which would be visible in the finished paint film. The surfaces of knots and resinous streaks shall then be painted with two coasts of knotting, the first being allowed to dry before the second is applied.

The surfaces of timber treated with a water-borne preservative by an impregnation process shall be rubbed down and dry brushed to remove all traced of efflorescence before the primer is applied.

Where surfaces are suspected of being infected with mould they shall be thoroughly treated with a fungicide.

7.6.14.34 Final Treatment of Wood, Plaster, etc.

The final painting system required in the works is given in the following table and is presented to tenderers for guidance to include such work in their supply under this Contract.

7.6.14.35 Paint Schedule for Plaster and Concrete Protection

The following schedule for Plaster and Concrete painting shall apply:

Surface	Environment	Primer	Final Treatment
Concrete and cement plaster	High humidity	1 coat of a highly weather resistant resin, thinned to manufacturer's instruction	2 coat of a highly weather resistant synthetic resin based paint

Surface	Environment	Primer	Final Treatment
Concrete	Exposed to oil	1 coat with a plastic modified hydraulic mortar	3 coats with an oil resistant synthetic resin-based paint
Concrete	Exposed to mechanical and chemical attack	1 coat of colourless 2-pack epoxy-based paint, thinned to manufacturer's instructions	2 coats of a 2-pack epoxy-based paint
Concrete flooring	Exposed to mechanical wear and oil	1 coat of colourless rubber-based paint, thinned to manufacturer's instructions	2 coats of a 2-pack epoxy-based paint
Internal concrete and plastered walls	Exposed to minor abrasion		3 coats of an oil-free synthetic resin-based dust-binding paint
Concrete flooring	Exposed to minor mechanical wear		2 coats of an oil-free synthetic resin-based dust-binding paint
Internal plastered	Exposed to normal conditions	1 coat of polyvinyl-acetate dispersion type, non-chalking, thinned to manufacturer's instructions	2 coats of polyvinyl-acetate dispersion type, non-chalking

7.7 Steel Structures and Engineering Metalwork

7.7.1 Scope

This section sets out the general requirements for the structural steel works and Engineering metalwork required in the works.

Structural Steel Works as specified hereunder shall include the supply of materials, erecting and site clearance after completion of Works.

The bid prices entered in the Bill of Quantities shall fully include the value of works described under the several items and shall cover the cost of all labour, subsidence, travelling, materials, temporary works, yards and stockpiles, sampling and testing and any other expenses whatsoever together with all risks, liabilities and obligations set forth or implied in the Contract Documents.

7.7.2 General

All steelwork (except roof structures and steel reservoirs) where ever installed shall be galvanised (hot dip or zinc spraying).

Welding of galvanised steelwork shall not be done and assembling at erection shall be exclusively by bolts and nuts.

The permissible design stresses for materials, bolts, rivets, etc., shall be as per DIN 18800, for welds as per DIN 4100.

Rolled structural steel sections shall be mild steel, conforming to DIN 17100.

The dimensions, tolerances and properties of the structural sections shall conform to DIN 18201 up to 18203 and to DIN 18800.

Where the use of prefabricated proprietary designs is proposed, the standards to which they are manufactures shall be no less rigorous than specified herein.

For structural steel works the following principal standards shall be applicable (list not limitative):

DIN 18800-1 Steel Structures, design and construction
DIN 18800-2 Steel Structures, stability, buckling of bars
DIN 18800-3 Steel Structures, stability, buckling of plates
DIN 18800-4 Steel Structures, stability, buckling of shells
DIN 18801 Steel Construction in building, dimensioning, design construction
DIN 18914 Round thin-walled steel silos

For structural steel work assemblies, steel bolts, nuts and washers shall be high strength friction grip bolts conforming to DIN 6914 up to DIN 6916 or black bolts including nuts and washers conforming to DIN 7989 and DIN 7990.

All welding consumables (electrodes, wire, filler rods, flux, shielding gas and the like) shall comply with the requirements of the appropriate DIN standard and with the requirements of the appropriate welding procedure.

7.7.3 Steel quality

The steel to be used for steel structures such as reservoirs is Steel Grade St 37-2 and shall be weldable. All railings, caged ladder and footbridges are steel grade ST 37-2 and the standard protective finish to all components is hot dip galvanizing.

Structural steel shall conform to the requirements as specified in the Standards and the design shall be based on the minimum properties for the steel to be normally used in the works are the following:

Tensile yield point fyk = 240 N/mm²
Tensile strength fyk = 360 N/mm²
Module of elasticity E = 210 000 N/mm²
Thermal coefficient of expansion T = 12 x 10-6 mm/m/°C

All steel furnished for structure shall be properly identified for conformity to the ordered grade through mill tests reports and certification shall be furnished that the yield point of the material supplied equals or exceeds that considered in the design.
Steel which is not readily identifiable as to grade from marking and tests records shall be tested to determine the conformity to the Standards at the Contractor's cost.

7.7.4 Design and Detailing

Structures and components, such as required for the laddering, hoppers, etc., shall be shop fabricated so as to form sub-assemblies of the largest practical size suitable for transportation, handling and erection.

Detailing shall be in accordance with DIN 18800.

7.7.5 Erection

All erection processes shall be carried out in accordance to DIN 18800.

At the commencement of the Contract, and before beginning to erect any steel structure, the Contractor shall submit for approval of the Engineer the erection plan and the procedure describing the methods the Contractor intends to use on Site.

The erection plan and procedure shall provide all complete details of the erection process. The erection plan shall include drawings, notes, catalogue cuts, and calculations clearly showing all necessary details, assumptions, and dimensions. Material properties, specifications, structural analysis, and other data used shall be included.

After receiving the approval by the Engineer, the Contractor can start the erection process.

7.7.6 Test Certificates

The Contractor shall furnish as many copies of mill orders and shipping statement as required to the Engineer.

7.7.7 Handling and storing of materials

All structural steel parts shall be transported safely and shall arrive sound without damage.

All storage facilities shall be subject to the approval by the Engineer and shall be such as to permit easy access for inspection and identification. All material shall be stored in that way to prevent rust and lost of small parts. Piled material shall not rest on the ground or in water but on skids or platforms.

Loading, transporting, unloading, and piling of steel material shall be conducted in that way that the steel will be kept free from injuries from rough handling.

In assembly of structural parts, the Contractor shall use methods and equipment not likely to twist, bend, deform or otherwise injure the material.

All members slightly bent or twisted shall be corrected before placing and all members seriously damaged will be rejected.

7.7.8 Welding and Heat Treatment

7.7.8.1 General

All welding carried out during fabrication in the factory and erection on the site shall be carried out in accordance with the requirements of DIN 4100 and as shown on the approved detail drawings.

Before welding is commenced either in the fabrication shop or on site, weld procedures shall be submitted for approval of the Engineer and weld procedure tests shall be carried out where directed by the Engineer. The procedures shall specify the type of equipment to be used, electrode selection, preheat requirements, base material, and joint details.

In the case, the procedures are not covered by Standards, evidence of qualification tests shall be submitted.

7.7.8.2 Preparation for Welding

No welding on galvanised steelwork and over zinc primers or paint shall be allowed.

7.7.9 Anchor Bolts

7.7.9.1 Placing anchor bolts

Anchor bolts are set by the Contractor in accordance with the approved drawing, and the bolts shall be set perpendicular to the horizontal surface of the foundation slab.

The contractor shall comply with the following requirements in setting anchor bolts in the reinforced concrete foundation slab of the water storage tank:

If set in wet concrete, the bolts shall be accurately placed before pouring the concrete,

If the bolts are set in drilled holes, the holes' clear diameter shall exceed the bolt diameter at least 25 mm in order to place the grout. Before placing grout, the concrete shall be thoroughly

cleaned, and wetted with water ensuring a proper bonding. Grout shall be pre-packaged and mixed, placed, and cured as recommended by the manufacturer. After 7 days the grout must have attained a minimum strength of 28 MPa (28 N/mm²). The Contractor shall to submit all information to the Engineer for approval before using the grout.

7.7.9.2 Anchor bolts

For fixing the steel shell of the water storage tank the contractor shall furnish and place anchoring bolts described as follows or similar products:

FISCHER resin anchor R (Eurobond), consisting of a threaded rod and the resin capsule, containing quick-setting styrene-free vinyl ester resin and hardener. The resin adheres at the surface of the threaded rod and bonds it to the wall of the drilled hole.

7.7.10 Flooring

7.7.10.1 General

Flooring shall be fabricated from chequer plate or open mesh panels.

Flooring and supports thereto shall be designed and manufactured to resist a uniform applied live loading of 7.5 kN/m² unless otherwise specified or stipulated in the applicable DIN Standards.

Flooring panels shall generally be removable by one man and the maximum weight of each panel shall not exceed 25 kg. Removable sections of flooring shall be provided with holes for lifting keys, keys to suit for each location, and be arranged to permit removal without disturbance to support brackets, spindles, pipework, etc. Intermediate support members shall be provided as required and attached to the supporting structure.

Flooring shall be detailed and fabricated so that no cutting is required on site. Flooring shall be secured to the kerbing or supports by stainless steel flush screws.
Supporting steelwork shall comply with the requirements of clauses for structural steelwork.

Bolt holes in brackets and mountings shall be slotted to allow for adjustment of line and level.

Mild steel continuous kerbing shall be provided for seating the flooring in concrete. Kerbing and other supporting structures for building into concrete shall have lugs welded on a maximum spacing of 600 mm. The width of any access walkway shall be not less than 750 mm.

7.7.10.2 Floor Covers and Grates

Covers or grates over openings in concrete or brickwork shall be set flush in mild steel framed kerbing provided with adequate integral lugs for building in.

Covers, grates and frames shall be heavily galvanised or aluminium alloys and shall have an anti-slippery profile.

Grates shall form a screen of fabricated from mild steel load bearing bars of flat section backed with round, square, or twisted bars perpendicular to and welded to each load bearing bar. Open mesh flooring shall be heavily galvanised.

Covers shall be trimmed across the ends of load bearing bars by flats of the same cross section welded to each load bearing bar. Covers shall be fixed to the kerbing or supporting steelwork with adequate flush stainless-steel screws or clips so that movement is prevented.

Cut-outs for plant items shall be trimmed with curved or straight edge trimming as appropriate.

Internal access covers shall generally be designed and fabricated as specified for flooring. In situations, which warrant special measures to prevent pollution of filtered water, the covers shall be airs tight.

If not anywhere otherwise required, external access covers over such as raw water or sludge channels shall be steel open meshes.

7.7.10.3 Permissible Tolerances

For metalwork at floor level joints differences between flooring sections and between steel flooring and adjacent concrete shall be:

- difference in level at joints: 3 mm
- joint gap: 3 mm

7.7.11 Handrailing

Handrailing shall be provided along every edge of all metalwork and concrete walkways, stairs or accessible open areas where the drop beyond the edge exceeds 700 mm.

Handrailing shall consist of standards at regular intervals not exceeding 1.5 m, and two rails. The upper rail shall be 1.0 m above the adjacent finished floor level, and 900 mm above the nosing line on stairways. The lowest rail shall be midway between floor and upper rail.

The handrailing fixing and anchorages shall be designed to withstand a continuous horizontal load at the top rail of 750 N/m.

Unless otherwise required in the particular specification standards for handrailing inside buildings, all rails shall be fabricated from 32 mm bore galvanised medium weight steel tube.

Handrailing shall be flush jointed. Handrailing terminating against a wall shall either have a suitable wall fixing flange, or shall terminate at a standard with a gap between the standard and the wall not exceeding 100 mm.

Where the shape of the concrete structure does not incorporate an upstand at the edge of walkways, toe plates 5 mm thick and 100 mm high shall be fixed to handrail standards. The bottom edge of such toe plates shall be 10 mm above the surface of the concrete walkway.

The handrail standards for stairways and for landings and walkways of width less than 1.2 m shall have palm fittings for bolting to the side of the structure.

Elsewhere the standards shall be designed for fixing 100 mm inside the edge of concrete structures, or at the supporting edge girder of steel flooring, or have palm fittings.

Horizontal mounting palms shall be drilled for not less than three bolts with two bolts on a line parallel to and on the walkway side of the line of the handrailing. Vertical mounting palms shall be drilled for not less than two bolts the line through the bolts being vertical.

Where required ladders, stairways or other openings shall be guarded on three sides by handrailing conforming to the requirements stated above. Access to the ladders or openings shall be guarded by two removable galvanised hanging chains secured to eyes at top and middle levels.

Handrailing shall be of uniform appearance and manufacture.

Aluminium alloy handrails and standards shall consist of tubular polished aluminium alloy. Standards shall be fitted with approved bases.

7.7.12 Ladders and stairways

7.7.12.1 General

Stairs shall have an inclination of approximately 30° and ladders of 750 where practicable. Stairs shall be complete with handrails, min. 100 cm vertical height.

Vertical ladders shall be installed alternating left hand/right hand side to horizontal platforms placed approximately every 6 m of vertical height. Vertical ladders of more than 3 m height shall be provided with safety hoops at intervals not exceeding 900 mm, with the lowest hoop 2.5 m above the ladder foot. Unless otherwise stipulated in the applicable standards live load assumptions for ordinary platforms shall be:

- for platforms used by personnel only with light equipment of weights not exceeding 50 kg - 2.5 kN /m²
- for all other platforms - 7.5 kN /m²

7.7.12.2 Ladders

Except for internal access ladders to water tanks, reservoirs and pump sumps, ladders shall be of steel grade ST-37-2; ladders for internal access shall be of stainless steel.

Generally, all ladders shall be in accordance with DIN 3620.

The stringers shall be sized to suit the height of the ladder and the interval of the stringer supports. Stringers shall be bent over the top and drilled to receive the rungs, which shall be welded to the stringers on each side of each stringer. The bottom ends of the stringers shall not be designed for floor fixing, but shall terminate at wall fixing supports at least 150 mm above the floor. All edges of stringers shall be ground smooth to remove burrs and sharp edges.

Where the installation of hoops is not possible or inappropriate, as agreed with the Engineer, anchorage points shall be provided for attaching safety harnesses.

7.7.12.3 Steel Stairways

Stairways shall be designed for a loading of 7.5 kN/m² of plan area of the stairway. Steel stairways shall be provided with tubular handrails, stringers of cross section suitable for the span and loading, and treads of open mesh flooring or chequer plating. Except where specified otherwise, the rise between treads shall be uniform and between 150 mm and 175 mm. Stairways in the same area of the works and in similar locations shall have the same angle and height of rise between treads.

The width of the treads shall be between 250 mm and 300 mm. The width of the stairways shall not be less than 750 mm.

The stringer shall be mounted by means of angle brackets with slotted holes for adjustment of line and level.

7.7.12.4 Step Irons

Step irons for buildings into pre-cast concrete and step irons and handholds for building into the wall of in-situ concrete manholes and chambers shall be of round pattern.

All step irons shall be galvanised or stainless steel.

7.7.13 Corrosion Protection

The structural metal work shall be protected in accordance with the general specification for "Painting and Protective Coating".

7.7.14 Installation

Where metalwork is to be founded on and fastened to concrete, the Contractor shall use one of the following methods as subsequently detailed:

Method	Description
1.	Bolting or screwing the metalwork to plates or angle sections with anchors set into the concrete structure or set into pockets left in the concrete structure.
2.	Setting the metalwork into pockets or recesses formed in the concrete structure.
3.	Bolting the metalwork to bolts set into the concrete structure or set in pockets or holes in the concrete structure.
4.	Bolting the metalwork to self-anchoring epoxy resin fixed bolts placed in drilled holes.
5.	Bedding the metalwork on cement-mortar placed on the concrete surface.

Cement-mortar of 1 part of cement to 3 parts of sand shall be used for bedding access covers and the like and for filling around metalwork or bolts set into pockets or holes smaller than 100 mm².

For larger holes, concrete of the same grade as the structure shall be used instead of mortar.
The installation methods permitted for each type of metalwork are specified in the table below:

Metalwork item	Permissible methods of installation
Stairs, ladders, flooring	1, 3 and 4
Step irons	2
Handrailing	3
Access covers, surface boxes and gully grating	2 and 4

During installation, each item of metalwork shall be temporarily braced as necessary to resist all forces, which are likely to be applied to it during installation, fixing and building in.

Any bolted connections required as part of the installation operation shall be fitted and tightened before fixing bolts are tightened or pockets are grouted.

The nuts of grouted or resin fixed bolts shall not be tightened until the grout has fully cured.

Small or lightly loaded items may be fixed using screws and approved plugs set in drilled holes.

7.7.15 Miscellaneous

7.7.15.1 Dissimilar Metals

The use of dissimilar metals in contact, liable to lead to galvanic action, shall be avoided where possible.

Galvanised mild steel surfaces in contact with aluminium or aluminium alloy shall be deemed to satisfy this requirement. Components of aluminium or aluminium alloy shall be fixed to steel structures exclusively be means, bolts, nuts, washers and screws which are cadmium plated.

7.7.15.2 Keys

Lifting keys and devices for unfastening screws shall be galvanised mild steel and supplied at the rate of one set for each five similar covers, with a minimum of two sets of each particular type.

8. MECHANICAL WORKS

8.1 General Requirements

8.1.1 General Regulations and requirements

The following directions, information and technical requirements for layout, design supply and erection shall be observed as far as they are applicable for all equipment to be offered. The technical requirements stated in the Technical Specifications are valid for all equipment, except only where additional and/or special requirements are specified.

Whenever a Tenderer deviates from these Specifications and Drawings, he shall furnish the data called for in the technical data sheets and give a summary of and the reasons for all deviations in a "List of Technical Deviations from Specifications". Failure to provide such a list may cause invalidation of his Tender, especially when a major deviation is involved.

Any changes of the design of any part of the equipment, which may become necessary after signing the Contract, shall be submitted in writing to the Engineer for approval, being sufficiently substantiated and justified.

Additional cost will only be accepted in case the EMPLOYER has changed the basis of the design after award of Contract. However, omissions on the part of the Contractor on specified items of work of this contract shall not be considered for additional cost.

The regulations, standards and guidelines listed in these Specifications shall be observed in the design, calculation and manufacture of all mechanical parts.

All parts of the plant shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions peculiar to the site.

It is further expected that all parts of the plant shall be adequately and generously dimensioned.

Special attention shall be given to equipment, parts of which are delivered by different manufacturers. Problems arising in this conjunction shall be solved by joint effort of all participants and shall be defined in writing.

8.1.2 Functionality

All plant shall be designed, manufactured and arranged so that it possesses a functional design and pleasant appearance. All parts of the works shall be arranged in a simple manner to facilitate surveillance by the operator, easy maintenance and operation, and all control movement shall be reasonable and obvious.

The parts of the plant shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without necessitating large scale dismantling of other parts of the works. They shall be designed and manufactured in accordance with the latest recognised rules of workmanship and modern Engineering practice.

For individual items of plant, materials and design are to be selected which are best suited for operating conditions to which the parts in question will be subjected. Only such design and types

of equipment shall be offered which have been tested in long-term continuous operation. Innovations cannot be accepted for the Main Tender but may be offered additionally as an alternative proposal.

8.1.3 Protection / safety

All live, moving and rotating parts shall be provided with appropriate effective protection in order to avoid danger to the operating staff. All metal parts shall be electrically grounded. Manufacturers shall take appropriate measure to prevent the ingress of dust into any equipment (such as bearings, relays, control and measuring equipment, etc.), which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where they are required or where they will be useful for erection and dismantling.

Sockets and depressions likely to hold water shall be avoided in the design, and if not avoid-able, they shall be properly drained.

Large or heavily loaded ball and roller bearings shall be protected against deformation and vibration during transport. If the bearings have been deformed, they shall be exchanged at site against new ones free of charge.

Parts of the plant intended principally for standby purposes shall be protected from corrosion by careful choice of material and by additional means; which should not reduce their continuous standby readiness.

8.1.4 Relevant Standards

The Contractor shall carry out works described in this Specification in accordance with the appropriate EN and DIN Standards. These are, but are not limited by, the following:

- EN 3 Portable Fire Extinguishers
- EN 294 Safety of machinery. Safety distances to prevent danger zones being reached by the upper limbs
- EN 593 Industrial valves - Metallic butterfly valves
- EN 773 General requirements for components used in hydraulically pressurised discharge pipes, drains and sewers
- EN 837-1 Pressure gauges. Part 1 : Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing.
- EN 1171 Industrial valves - Cast iron gate valves
- EN 1452 Plastics piping systems for water supply - Unplasticized polyvinyl chloride (PVC-U)
- EN 1561 Founding. Grey cast irons
- EN 1563 Founding. Spheroidal graphite cast irons
- EN 1676 Aluminium and aluminium alloys. Alloyed ingots for remelting. Specifications.
- EN 1706 Aluminium and aluminium alloys. Castings. Chemical composition and mechanical properties.
- EN 1982 Copper and copper alloys - Ingots and castings
- EN 10083 Steels for quenching and tempering
- EN 10088 Stainless steels

- EN 10216 Seamless steel tubes for pressure purposes
- EN 10217 Welded steel tubes for pressure purposes
- EN 10255 Non-alloy steel tubes suitable for welding and threading
- EN 10293 Steel castings for general Engineering uses
- EN 12334 Copper and copper alloys - Ingots and castings
- EN 12540 Corrosion protection of metals

- ISO 898 Mechanical properties of fasteners made of carbon steel and alloy steel
- ISO 1217 Displacement compressors. Acceptance tests
- ISO 1461 Hot dip galvanised coatings on fabricated iron and steel articles. Specifications and test methods
- ISO 3046 Reciprocating internal combustion engines
- ISO 7005 Metallic Flanges
- ISO 8528 Reciprocating internal combustion engine driven alternating current generating sets
- ISO 9905 Technical specifications for centrifugal pumps
- ISO 5199 Technical specifications for centrifugal pumps - Class II
- ISO 9908 Technical specifications for centrifugal pumps - Class III
- ISO 9906 Rotodynamic pumps - Hydraulic performance acceptance tests

- DIN 2403 Identification of pipelines according to the fluid conveyed
- DIN 2501 Flanges; Connecting Dimensions
- DIN 2642 Loose flanges
- DIN 3230-4 Technical Conditions of Delivery for Valves; Valves for Potable Water Service, Requirements and Testing
- DIN 4100 Welded steel structures
- DIN 4114 Steel structures stability
- DIN 4132 Crane ways, steel structures, calculations and design
- DIN 4056 Water pipelines; valve boxes for stop valves; DVGW code of practice
- DIN 8974 Polyethylene (PE) pipes - Dimensions
- DIN 15018 Cranes, steel structures, stress analysis
- DIN 15020 Lifting applications basic principles for Rope Receiving components
- DIN 15030 Cranes, acceptance ad testing of cranes

The Contractor may carry out the works or provide materials in accordance to local or other international standards (BS, ISO and others), provided their requirements are superior or equivalent to the quality described by the standards cited in the Specifications.

8.1.5 Standardisation of equipment

As far as possible, measures shall be taken to standardise certain parts of the equipment throughout the works to be installed under the present project in order to facilitate keeping stocks, maintenance, replacement and interchange ability.

The types and makes of equipment to be used shall be as per vendor list and/or approved by the Engineer, if the same is not mentioned in the vendor list.

All instrument indicator scales shall be in the English language with units in the international SI-System.

8.1.6 Identification plates

As far as applicable, all parts to be delivered under the Contract shall be labelled with permanent identification plates in readily visible locations. The identification plates shall be protected during erection and especially during painting. Damaged or illegible identification plates shall be replaced. The identification plates shall be of non-corroding, non-disintegrating material and shall be labelled in English language.

Printed or stencilled inscriptions shall be waterproof, oil-proof and wear resistant. Equipment (machines, transformers, etc.) nameplates shall be of enamelled type or stainless steel coated with a transparent lacquer.

The following data shall be shown in accordance with the relevant standards:

- Manufacturer's name and address;
- Manufacturer's serial number and date of manufacture;
- Main design data.

Standardised components, such as small or medium sized electric motors, transformers, instruments, etc., with the manufacturer's standard nameplate are acceptable.

Each part appearing under a certain symbol or number in functional diagrams, piping diagrams, operation and maintenance instructions, etc., shall be equipped with a plate showing the same symbol or number.

Warning signs and plates for designations or instructions for operation, safety and maintenance shall have a uniform design and shall be inscribed in English and Swahili language.

8.1.7 Instruction manuals

The Contractor shall submit to the Engineer not later than two months before commissioning, duplicate draft copies of the Operating and Maintenance Instructions in Spanish for all sections of the works. The operating instructions shall be prepared in such a way as to provide a step-by-step description of the preparation and setting to work of the whole of the works and its shutting down.

The instruction manuals prepared by the Contractor and manuals relating to plant by any sub-contractors shall be printed (not duplicated) and shall be bound into suitable loose-leaf binders A4 size.

Following successful commissioning and not later than two months after the Contracting Authority has taken over the works, the draft copies, suitably corrected where necessary, shall be assembled into their final form and shall be submitted to the Engineer for approval.

The Contractor's attention is drawn to the need to ensure that the following items are included in the manuals:

- Schedule of equipment supplied, giving manufacturers name and model No.
- Schedule of routine maintenance for all equipment supplied.
- Schedule of spares supplied
- Schedule of tools and lubricants supplied
- Sectional arrangement drawings of major items of plant, i.e., pumps, valves etc., with dismantling instructions.
- Plant layout drawings showing the "As Erected" installation.
- •General arrangement and schematic diagrams of the "As Installed" control panels
- "As Wired" diagrams of all electrical connections
- Full and comprehensive instructions for all items of equipment supplied.
- Test certificates for all equipment for both works and site
- Schedule of recommended lubricants and their equivalents.

At each location for each type of equipment there shall be supplied and mounted on the wall in a conspicuous position:

- 1 board mounted Schedule of Routine Maintenance to be carried out on plant
- 1 board mounted Set of Instructions for Operation of the plant

The print on each board is to be of large clear type in Swahili and English. The issuing of the Maintenance Certificate shall be subject to receipt and approval of Operating and Maintenance Instruction by the Engineer.

8.1.8 Materials

For general requirements concerning the quality of materials and equipment refer to the relevant clauses in the Conditions of Contract.

No welding, burning, filling or plugging of defective castings or any other components shall be permitted without the Engineer's approval in writing. Any steel castings, which have been repaired by welding with the Engineer's consent, shall be subjected after the final heat treatment to whatever crack detection, radiographic and/or gamma ray examination or any other tests which the Engineer may require. The cost of these and other additional tests shall be borne by the Contractor.

Where stainless steel cladding consists of plates welded to mild steel sections, the welds shall be adequate to ensure that the stainless steel is securely fixed for all conditions of load and wear. Generally, all stainless-steel parts shall be welded with stainless electrodes. The thickness of the stainless-steel cladding shall not be less than 3 mm.

8.1.9 Allowable noise levels

The noise level definition and measurement shall be in accordance with the relevant ISO and IEC standards. The noise level caused by the installed operating equipment shall not exceed the following values, if not otherwise stated:

- In the pump house, at any place 1m from operating equipment max. 80 dB(A)
- In offices, control rooms, etc. max. 55 dB(A)
- In residential areas (daytime) max. 50 dB(A)
- In residential areas (night time) max. 35 dB(A)

The Contractor shall furnish to the EMPLOYER one calibrated noise-measuring instrument during the commissioning period of the equipment.

8.1.10 Colour code

The colouring of piping for various media, moving parts, etc., shall be in accordance with DIN 2403. Pipework, tanks and ducting shall be colour coded by totally painting with the appropirate code colour as specified. The principal code colours shall be as follows:

• Potable water	Blue
• Hot water	Crimson
• Raw water	Light green
• Irrigation water	Medium green
• Waste water	Dark green
• Firefighting water (including sprinkler systems and hydrants)	Signal red
• Oil and fuel oil	Brown
• Gas for fuel	Yellow ochre
• Chlorine liquid and gas	Yellow
• Compressed air	Light blue
• Air (ventilation and air conditioning ducts)	Silver

All pipes and tanks shall also bear stencilled labels to indicate the contents. Lettering shall be in both Swahili and English. Labels on pipework shall incorporate arrows showing the direction of flow within the pipework.

Black lettering shall be used on orange, yellow and green background and white lettering shall be used on red and blue. Sufficient labels shall be used to ensure adequate identification throughout the length of the pipe runs. These shall be located at least adjacent to each flange or disconnecting joint, where pipework passes through walls, floors, crosses doorways and other access ways and at intervals in long runs of pipework.

8.1.11 Corrosion protection

8.1.11.1 Painting

refer to 7.6.14

8.1.11.2 Galvanising

Steel structures specified to be galvanised and screws, nuts, etc., associated with galvanised parts shall be hot-dip galvanised, electrolytically galvanised or sherardised, as appropriate to the particular element. Galvanising shall conform to the DIN or approved equivalent standards.

Original blast-furnace raw zinc with a purity of 98.5% shall be used for galvanising. The thickness of the zinc coat shall be:

- For screws and nuts, not less than 60 micrometres;

- For all other parts, except for hydraulic steel structures or parts intermittently or permanently submerged in water, not less than. 70 micrometres;
- For hydraulic steel structures or parts intermittently or permanently submerged in water, not less than 140 micrometres.

All material to be galvanised shall be cleaned carefully of rust, loose scale, dirt, oil, grease and other foreign substances. Particular care shall be taken to clean slag from welded areas.

Where pieces to be galvanised are of such lengths that they cannot be dipped in one operation, care shall be exercised to prevent warping. Galvanised compression members of steel structures shall not have lateral variations greater than 1/1,000 of the axial length between the points of lateral support. Galvanised tension members shall not have lateral variations exceeding 3 mm for each 1.5 m of length.

Warped plates and members which require reshaping after galvanising shall not be hammered or otherwise straightened in a manner that will injure the protective coating. All galvanised material shall be free of excess smelter after galvanising.

Material on which galvanising has been damaged shall be re-dipped unless the damage is local and can be repaired by soldering or by applying a galvanising repair compound. In this case, the compound shall be applied in accordance with the manufacturer's instructions. Any member on which the galvanised coating becomes damaged after having been dipped twice shall be rejected.

8.1.11.3 Chromium plating

All chromium plating shall comply with EN 12540.

8.1.11.4 Warranty

The general guarantee and maintenance periods as stated in the Conditions of Contract shall not apply to protective coatings work.

The guarantee period for all painting shall be five years, commencing from the issue of the "Certificate of Completion". These protective coatings guarantee period shall be effective regardless of any other guarantee periods for the project or parts of the project, or any "Certificate of Maintenance", issued prior to the elapse of the painting guarantee period. The Contractor shall perform requested painting repair work at no charge to the Contracting Authority if the painting quality guarantee is not met during the guarantee period.

8.1.12 Allowable stress

The design of all parts of equipment shall be based fundamentally on the severest exceptional conditions to which they will be exposed during operation and testing. The stresses which occur in that section of the part when exposed to the severest exceptional operating conditions or test pressure, shall not exceed 70 % of the yield point of the material of the respective part, unless otherwise specified.

When exposing complicated steel castings or welded parts to the pressure test, the maxi-mum allowable stress limit of 70 % of the yield point may be exceeded locally in limited zones, if these zones are small in extent and do not endanger the overall strength of the part. To check these

stresses in the critical zones, the Engineer may require strain gauges to be mounted during pressure tests.

In the design of the equipment, the maximum stresses due to normal operating conditions shall not exceed one-third of the yield point or one-fifth of the ultimate strength of the mate-rial.

Increased size or thickness, i.e., at least 1mm, shall be required for members subject to corrosion or erosion and for members mainly designed for rigidity. The dimensions of the parts which are exposed to repetitive and alternating stresses as well as to impacts and vibrations shall take into account the safety measures approved in practice.

The calculations performed by the Contractor when dimensioning the main parts of the equipment shall be submitted to the Engineer at his request.

8.1.13 Welding

8.1.13.1 General

All welding works shall be applied under most convenient working conditions, utilising mod-ern, effective equipment and techniques and latest welding technologies. All welding shall be performed by welders qualified and experienced in the particular type of welding required. It shall be the responsibility of the Contractor to ensure that all welding operators are properly qualified and competent to carry out all required field welding.

Records of the welding procedures and welder performance qualification tests for work done shall be maintained by the Contractor for review by the Engineer. The method and procedure adopted for welding in workshops and at site shall be approved by the Engineer be-fore production starts.

All welds shall be shown in the detailed drawings as well as the welding sequence to mini-mise residual shrinkage stresses. For the various structures and plates to be welded, the Contractor shall submit adequate information concerning the proposed:

•Weld profiles for each type and size of weld type required, shop and field welds;
•Extent to which automatic and manual welding techniques will be applied;
•Use of pre-weld heat treatment, post-weld stress relieving, full anneal stress relieving or normalising;
•Weld electrodes, welding wire and flux to be used (also to be stated on drawing);
•Standard tolerances for the deviations of mating weld profiles and the root gap tolerances.

8.1.13.2 Preparative works

Pieces to be joined by welding shall be cut accurately to size including the allowances. Welding edges shall be sheared, flame-cut or machined. The faces to be welded shall be free of all visible defects, such as laminations, surface defects caused by shearing or flame-cutting operations and free of rust, mill scale, grease, oil paint or any other foreign matter. Freedom from laminations shall be checked with ultrasonic or dye penetrate methods.

Welding over zinc primers shall be permitted subject to submission of a certificate of recognised institution, stating the limiting pertinent parameters for this welding procedure. In all other cases, welding over paint shall be prohibited; all painting materials next to the joint to be welded shall be

removed for a distance 6 times the plate thickness, subject to 80mm minimum and 150mm maximum in the case of automatic welding.

Temporary or permanent welding shall not be permitted on areas where the welding will damage paint or other protective coatings, unless the areas of coatings, which would be damaged thereby, are accessible for repair and inspection.

8.1.13.3 Welding works

The standard of welding works shall be in accordance with relevant EN or DIN standard and the directions of the plate and electrode manufacturers. All welding (except welding of thin plates or piping of small sizes) shall be performed by the electric-arc method and where practical, under procedure control using automatic machines.

For any welding work, only the appropriate welding rod, either arc or gas, shall be used. The properties shall conform to the material to be welded as specified in the respective standards. The electrodes for arc-welding shall be classified on the basis of mechanical proper-ties of the as-welded deposited weld-metal, type of covering, hydrogen absorption, welding position of the electrodes and type of current.

Electrodes shall be used only in the positions and under the conditions of intended use in ac-accordance with instructions for each type and with all safety precautions. Electrodes for manual welding shall preferably be the heavily coated type and shall be suitable for welding in any position. Tacks shall be removed before welding. Electrodes shall be dried in electric ovens before use.

After being cooled and deposited, welds shall be cleaned of slag and shall show uniform sections, smoothness of weld metal, feather-edges without overlap, and freedom from porosity and clinker. Visual inspection of the ends of welds shall indicate good fusion with the base metal.

Where weld metal is deposited in successive layers, each layer shall be thoroughly preened before the next layer is applied, unless otherwise approved by the Engineer. Particular care shall be taken in aligning and separating the edges of the members to be joined by butt-welding so that complete penetration and fusion at the bottom of the joint shall be ensured. All pinholes, cracks and other defects shall be repaired by chipping or grinding the defects to sound metal and re-welding. Where fillet welds are used, the members shall fit closely and shall be held together during welding.

The ignition of weld electrodes shall not be started at the plate beside the weld, but at the seam flanks to prevent detrimental increments of local hardness. Where ignition points of electrodes are discovered, they shall be ground appropriately.

Where auxiliary structural members are welded to components for the purpose of assembly or installation, the connecting welds of these shall be given particular care. The auxiliary structural members shall be removed not by knocking them off, but by burning, followed by grinding the affected areas flush with the plate, without producing additional thermal stresses.

8.1.13.3.1 Welding of carbon steel

Manual, shielded metal-arc, submerged arc, gas metal-arc, flux-cored arc, gas tungsten arc, and other applicable welding processes and methods may be used in the construction and fabrication of welded carbon steel equipment. Prefabrication in workshop shall as far as possible be used.

8.1.13.3.2 Welding of stainless steel

The welding method which shall be used, shall be the tungsten inert gas method (TIG) or the metal inert gas method (MIG) for both workshop welding and site welding. For workshop welding the metal arc, plasma method is also approved. Irrespective of the method chosen, the inner surface of the welds shall be protected by clean inert gas.

In order to guarantee high quality welded joints, piping and other quality stainless steel equipment shall as far as possible be prefabricated in the workshop. Furthermore, for stain-less steel welding the following shall be noted:

- Only butt weld jointing of the pipes is allowed during the erection work
- Where butt welds are used, the penetration shall be completed, if necessary, with root run
- Backing rings shall not be used
- No surface defects reducing the corrosion resistance or discoloration of the surface will be accepted
- After welding, the welds shall be carefully pickled and passivated
- The welds must be thoroughly washed in clean water after pickling and passivation
- Sand blasting will not be permitted for stainless steel.

8.1.13.3.3 Heat treatment

All weld-fabricated parts and castings except minor parts, parts where stress is not important or parts which are specifically exempted from stress relieving shall be designed, fabricated, stress relieved and inspected in accordance with an approved "Boiler and Pressure Vessel Code". All such parts shall be stress relieved as a unit prior to final machining.

Heat treatment of field erection welding seams shall be performed according to the specifications for the welding procedure for the corresponding parts, which shall be submitted to the Engineer for approval.

8.1.14 Materials

All materials incorporated in the Works shall be the most suitable for the duty concerned and shall be new and first-class commercial quality, free from imperfection, and selected for long life and minimum maintenance.

8.1.14.1 Wrought Steels

Where not otherwise specified, wrought steel parts shall be selected from appropriate grade of EN 10083 and be free from blemishes, shot or hammer marks. The Contractor shall submit for the approval of the Engineer, the grade number selected for the various components.

8.1.14.2 Cast Molybdenum

Cast Molybdenum steel shall be supplied to EN 10293.

8.1.14.3 Cast Iron

All grey iron castings supplied shall be to the appropriate grade in EN 1561. All castings are to be free from blowholes, flaws and cracks.

The Contractor shall replace any casting which the Engineer considers is not of first class appearance or in any way is not the best which can be produced, although such a casting may have passed the necessary hydraulic or other tests. No plugging, filling, welding or "burning–on" will be acceptable.

8.1.14.4 Bronze

Where not otherwise specified, bronze shall be strong, durable and zinc free acc. to EN 1982.

8.1.14.5 Aluminium and Aluminium Alloys

Due to the corrosive atmosphere, the use of aluminium or aluminium alloys requires the approval of the Engineer in all cases. Alloys shall be of types used for marine applications where magnesium is the main addition. Castings shall be manufactured according to EN 1676 and EN 1706.

Full details of the composition of each alloy shall be supplied to the Engineer for approval, before commencing manufacture. Immersed structures or structures that are periodically immersed shall not be constructed from aluminium or aluminium alloys.

8.1.14.6 Stainless Steel

Stainless steel shall be provided in accordance with Grade 316S13 to EN 10088 if not specified otherwise.

8.1.14.7 Finish

All covers, flanges and joints shall be properly faced, bored, fitted, fixed, hollowed, mounted or chamfered as the case may be, according to the best approved practice and all working parts of the plant and other apparatus, shall similarly be well and accurately fitted, finished, fixed and adjusted.

8.1.15 Spare parts and tools

8.1.15.1 General requirements

All spare parts to be supplied shall be interchangeable with the corresponding parts of all the equipment supplied and shall be of the same material and workmanship. Spare parts will not be accepted before the Contractor has submitted the complete list of all spare parts.

All spare parts shall be protected against corrosion and provided with identification labels in English and Swahili language. All spare parts shall be delivered in marked boxes of sufficiently sturdy construction to withstand five years of storage.

8.1.15.2 Required amount of spares

At least the quantity of general spare parts listed below shall be included as a minimum in the scope of supply of the Contract.

For a number of identical assemblies or items, general spare parts as indicated below shall be delivered, one set of which shall be defined as the total quantity of one assembly. The quantity "X" to be supplied is a function of the number "N" of supplied assemblies, subassemblies, or items identical in type and size:

- N < 3 X = 1
- N < 10 X = 2
- N > 10 X = N/10 + 1 rounded to the next higher whole number

General spare parts to be supplied:

- X sets of packing, seals, gaskets, bushings, springs, wearing parts of couplings, drive belts, etc., for each identical element such as motors, pumps, compressors, blowers, etc.;
- X sets of seals, gaskets and packing, plus X complete spare units for valves and gates;
- X + 1 of identical gaskets for pipe work but at least three;
- X + 1 assemblies or subassemblies of all filter elements;
- X + 1 assemblies or subassemblies of all measuring / control instruments, limit switches, relays, etc.;
- 5 % but at least two pieces of all bolts (except foundation bolts), screws, nuts, washers, etc.; the quantity may be taken from the surplus material at completion;
- 5 % of the quantity of painting material but at least one litre, in unused sealed containers, for repair work other than the Contractor's.

If any additional spare parts are recommended by the Tenderer, these shall be stated in quantity and description in the Technical Data Sheets for each item. Prices for additional recommended spare parts shall not be included in the Tender Price. Orders for additional recommended spare parts shall be optional for the EMPLOYER for a period of five years after the date of Contract award at the price indicated in the Tender.

8.1.15.3 Tools

The Contractor shall include in his supply all customary and special tools as well as special devices including lifting devices, ropes, etc., necessary for total assembly, disassembly and maintenance of all parts of the supplied equipment.

The costs for spare parts shall be included in the unit prices.

The standard set of maintenance tools shall comprise, if not otherwise directed or specified:

- 1 set of chrome vanadium spanners to fit each size of nut and bolts used throughout the installation;
- 1 set of screwdrivers to fit each size and kind wrench;
- 1 set of star screwdrivers to fit each size and kind of screws used throughout the installation
- 1 no. grease gun
- 1 no. lantern ring extractor if required
- 1 set insulated pliers
- 1 set keys
- 1 set of hammers (0,5-2kg);
- 1 no. adjustable Stilton
- 1 no. packing extractor

The use of special tools and devices for erection shall be allowed but must be approved by the Engineer in each case. Special tools and devices shall be provided with means for ready identification. Special tools and devices shall not be accepted before the Contractor has submitted the complete list of special tools and devices.

The total price for tools and devices, as required by this clause, shall be included in the Ten-der Price.

8.2 Supply, Erection and Handling of plant

8.2.1 Protection and packing for dispatch

Before dispatch from the Manufacturer's works all Plant shall be adequately protected by painting or by other approved means for the whole period of transit, storage and erection against corrosion and accidental damage. The Contractor shall be held responsible for the Plant being so packed and/or protected as to ensure that it reaches the Site intact and un-damaged.

All plant and equipment as necessary shall be packed in first quality containers or packing; no second-hand timber shall be used. The Plant shall be packed to withstand rough handling in transit and all packages shall be suitable for several stages of handling via sea or air freight, inland transport and movement on site and for storage including possible delays in delivery. Packing cases shall be of the fully boarded type, slated cases will not be allowed.

Precautions are to be taken to protect shafts and equally unprotected surfaces where they rest on wooden or other supports likely to contain moisture. At such points wrappings impregnated with antirust composition or vapour phase inhibitors are to be used of sufficient strength to resist chaffing and indentation due to any movement which is likely to occur in transit. The form and size of the protective wrappings and impregnation are to be suitable for a minimum period of twelve months.

Lids and internal cross battens of all packing cases are to be fixed by screws and not nails. Hoop metal bindings of cases are to be sealed where ends meet and if not of corrosion resistant material, are to be painted. Contents of such cases are to be bolted securely or fastened in position with struts or cross battens and not with wood chocks, unless they are fastened firmly in place. All struts or cross battens are preferably to be supported by cleats fixed to the case above and below to form ledges on which the battens may rest. Cases are to be up-ended after packing to prove that there is no movement of contents.

Where parts are required to be bolted to the sides of the cases, large washers are to be used to distribute the pressure and the timber is to be strengthened by means of a pad.

Waterproof paper and felt linings are to overlap at seams by at least 12 mm and the seams secured together in an approved manner, but the enclosure is to be provided with screened openings to obtain ventilation.

The flanges of pipes, valves and fittings shall have their open ends protected by adhesive tape or jointing and then be protected by wooden discs secured by means of service bolts (which shall not be used on site) or by other approved means. The sleeves and flanges of flexible couplings shall be bundled by wire. Cases containing rubber rings, bolts and other small items shall not normally weigh more than 500 kg gross.

All relays, instruments, etc. shall be shipped with transport screws and/or clamps, clearly marked and painted red, to prevent movement of moving parts. Reference shall be shown in the operating and maintenance instructions, detailing the removal of these temporary fixings prior to setting the equipment to work.

Structural steel work, pipes, valves, uncased fittings and metalwork shall be similarly marked. In addition, one in every ten repeated articles shall bear the dispatch marks in suitable paint or other approved medium. When in the opinion of the Engineer the dispatch marks cannot be applied satisfactorily to any item, they shall be stamped on a metal label attached to the item or part by means of a piece of wire passing through holes at either end of the label and secured so that it lies flat with the item.

Indoor items such as electric motors, switch and control gear, instruments and panels, ma-chine components, etc., are to be 'cocooned' in aluminium or polythene sheeting, sealed at the joints and the enclosures provided internally with an approved desiccate.

All items of Plant shall be clearly marked for identification against the packing list, Swahili and English language. All cases, packages, etc., shall be clearly marked on the outside with a waterproof material to show the weight, where the weight is bearing, and where the slings should be attached and shall also have an identification mark relating them to the packing lists and to the appropriate shipping documents. Cases shall bear the Contractor's name and the name of the particular site. These shall be marked in stencils or legible letters and shall be in red or black waterproof paint or protected by shellac or varnish to prevent obliteration in transit.

Each crate or package is to contain a packing list in a waterproof envelope and copies in du-plicate are to be forwarded to the Engineer's Representative on Site, prior to dispatch. All items of material are to be clearly marked for ready identification against the packing list.

The Contractor shall be deemed to have included in the Contract Price for all materials and packing cases necessary for the safe conveyance and delivery of the Plant.

The Engineer may require to inspect and to approve the packing before the items are dis-patched but the Contractor is to be entirely responsible for ensuring that the packing is suit-able for transit, and such inspection will not exonerate the Contractor for any loss or damage due to faulty packing.

The Contractor shall send advice of dispatch to the Engineer's Representative on site and the Engineer so that this information is received not less than two weeks before the anticipated delivery of the goods.

8.2.2 On Site storage and safekeeping

The Engineer shall agree machinery delivery dates with the Contractor within 60 days of the award of the Contract, and these shall be in accordance with the Contract. In case of de-lay to the Civil Works programme, to prevent delay to the shipment of Plant or the deterioration of Plant stored at Site, the Contractor shall either:

•Adequately package all items of Plant to enable the Plant to be stored in the open on Site without any deterioration whatsoever.
Provide an approved store, complying with the following minimum requirements on Site which will also prevent any deterioration of the Plant:

Electrical equipment: covered, air conditioned, dust proof and vermin proof area.
Rotating mechanical machinery: covered area.
Pipes, valves, steelwork, etc.: sheeted on open hard standing area.

The sheeting to be used shall be of a type that will not deteriorate in ultra–violet light. The machinery shall be ready for erection at Site by the end of the Manufacturing and carriage periods but if the machinery is complete and ready for erection before the agreed date, the Contractor shall arrange on site storage as defined herein, at his own expense within the Contract Price.

The Contractor shall provide insurance and shall be entirely and solely responsible for the security of all such Plant stored at the Site for the period until erection. The Contractor shall be responsible for inspecting all equipment prior to storage and he shall arrange for any damaged equipment to be rectified prior to delivery to store. The Contractor shall remove the machinery from storage and deliver to the final point of installation upon receipt of the Super-visor's Representative's instruction. The Contractor shall be responsible for the operation, safe keeping and maintenance of all equipment on site during and after erection up to the is-sue of the Completion Certificate.

8.2.3 Unloading, erection and running-in of plant

The Contractor shall make his own arrangements for the unloading of the Plant supplied at site or store and be responsible for any damage occasioned. The Contractor shall at his own expense provide all equipment, tools, meters, gauges, temporary accommodation, all skilled and unskilled labour, for the erection of the whole of the Plant and apparatus so that it can be installed complete and left in good working order.
Before commencing this work the Contractor shall examine the structure and make arrangements with the Engineer so that the Plant may be installed without interfering with the works and the running of the plants in course of construction and shall deliver to site items required to be "Built–in" prior to delivery of the main plant. The Contractor must expect erection at site to be discontinuous to suit the continuous running of the existing plants and the Contractor shall be deemed to have included a suitable allowance for this.

Any special erecting tackle required shall be provided by the Contractor and be left at site after the completion of the Contract. The Contractor shall provide adequate protection for the plant from the time it is delivered to Site until the Maintenance Certificate is issued. In particular, the Contractor shall provide and fix adequate sheeting, etc., to prevent the ingress of dust and dirt both during erection and whilst the building finishes are carried out after erection.

Upon the complete erection of the whole of the plant and auxiliary apparatus, the Contractor shall set the Plant to work in conjunction with arrangements to be made with the Engineer. The date of commencement of the twelve months maintenance period shall be on receipt of a notice in writing from the Engineer to the Contractor intimating that the entire Plant has been satisfactorily tested, has obtained the guarantees and that the Maintenance Certificate has been issued. The Contractor shall instruct the EMPLOYER 's employees who may be appointed to take charge of the plant in all matters and things relating to the proper running, adjusting and maintaining of the plant in efficient condition.

The Contractor shall provide a suitably qualified and authorised Engineer to act as site manager to co–ordinate the activities of the various sub–contractors for the whole period covered by the Contract. The Contractor shall also provide suitably qualified and competent specialist personnel employed for:

•The erection and checking of the Plant.
•The necessary liaison with the Engineer's Representative, Statutory Authorities and other Contractors.
•Supervision during the safekeeping, site testing, commissioning and maintenance periods.

At the end of the programme, the Contractor shall commission the equipment to the satisfaction of the Engineer who will then issue the Maintenance Certificate. Until such certificate is issued, the Contractor shall be responsible for the making good of any damage occasioned, however caused.

8.2.4 Commissioning, completion and maintenance

8.3 Mechanical equipment

8.3.1 Screws, bolts and nuts

All bolts, screws, anchor bolts, etc., including sleeves, nuts, washers, locking devices, etc., required for all equipment and accessories to be supplied under this Contract shall be furnished. Except for those consisting of stainless materials, they shall be adequately treated against corrosion before dispatch from the works. All threads shall be greased carefully during installation except where otherwise specified. Split pins or other approved locking devices generally shall be provided for nuts which may become loose due to vibration, etc.

All bolts, nuts, screws and other devices used to fix, clamp or adjust any parts, which are of stainless steel, or exposed to water or high humidity, or subjected to frequent adjustment or frequent removal shall be of corrosion resisting steel or bronze. All other bolts and pins shall be of carbon steel.

When in position, all bolts or screwed rods shall project through the corresponding nuts, but this projection shall not exceed three threads, unless more length is required for adjustment.

The Contractor shall supply the net quantities plus 5 % of all permanent bolts, screws and other similar items and materials required for installation of the works at the site. Any such rivets, bolts, screws, etc., which are surplus after the installation of the equipment has been completed, shall become spare parts and shall be wrapped, marked and handed over to the Engineer.

8.3.2 Drives

8.3.2.1 Bearings

All bearings shall be generously rated and sized to ensure satisfactory and stable running without vibration under all conditions of operation for a minimum running lift of 50,000 hours. They shall be sufficiently lubricated and adequately protected from ingress of moisture and sand and the particular climatic conditions prevalent at the site. All bearings shall be to ISO Standard SI unit dimensions.

8.3.2.2 Gearboxes

Standard enclosed gearboxes for machines shall be obtained from an approved manufacturer where necessary. The gearbox shall be designed to operate with the output shaft tilted to the required

angle of inclination without lubricant leakage. The input shaft shall be horizontal where possible and appropriate.

All gearboxes shall be suitable for outdoor installation and shall be de-rated considering continuous operation and heavy shock loads. Service factor shall not be less than 2. The thermal horsepower rating of the gear reducer shall exceed the motor horsepower after de-rating for 50°C ambient temperature. The gear-box selection shall be checked for momentary over-loads and overhung of radial and thrust loads.

Gearbox housings shall be of rigid high-strength close grained cast iron with provisions for:
•proper closing inspection cover,
•ventilation opening,
•oil level gauge,
•gauge window protection.

The ingress of moisture into the gearbox shall be prevented and splash and leakage water, etc., must be able to drain off easily. The transmission of power shall be achieved by means of precision gears. Helical gears shall be used. Cylindrical gears having helical or herring-bone teeth shall be precision ground for close tolerance operation.

All gears shall be amply designed, both with regard to surface durability and bending strength, guaranteeing a life span of at least 100,000 hours running.

The gearbox shafts shall be solid forging of the parallel type, precision ground and made from heat-treated hardened and tempered chrome-molybdenum alloy steel. Gearbox shafts shall be mounted on tapered roller bearings of double row anti-friction self-aligning spherical roller bearings (or as recommended by the gearbox manufacturer) capable of handling radial and thrust loads simultaneously and guaranteeing a life of at least 50,000 hours running.

Lubrication of the gear teeth surfaces shall be achieved by being immersed in the oil contained in the gearbox housing. For this purpose the gearbox shall be oil-tight and shall be such as to prevent the total loss of oil from the gearbox in the event of the failure of the oil seals. The whirling oil and the oil dripping from the surfaces shall lubricate the bearings.

Where immersion or splash lubrication is not effective, gears and bearings shall be lubricated automatically by a forced lubrication system. Lubricants shall be as or equal to that recommended by the manufacturer of the gearbox. Provision shall be made in the design of gear-boxes for oil filling and drainage. If the drain is not easily accessible, the gearbox shall be equipped with an outlet hose and small hand pump.

The gearbox shall be provided with a flexible overload coupling (including safety guards) be-tween the motor and the input shaft of the gearbox. Parts subject to wear must be easily re-placeable without disassembling the motor.

Particular care shall be taken in designing gearbox arrangements to protect the works or water under treatment from contamination arising from accidental overflow, any future leakage due to excessive wear, seal failure, or poor filling or drainage practices. Drip and catch trays and the like shall be generously provided throughout the works.

8.3.2.3 Couplings

Couplings shall be generously rated to cover the full range of duties. Couplings liable to impregnation by oil shall be of the all metal flexible type. General service couplings shall be of the flexible multi-pin and bush type, having not less than six bushes and each bush shall have an inner sleeve to allow rotation on the pin (bushes shall not be in direct contact with the pin). All pins shall have shoulders to allow positive location and securing to the bosses. Bosses shall be a tight fit on the shafts and secured with hand fitted keys.

Couplings shall be supplied in matching balanced sets and shall be machined, balanced and marked before leaving manufacturer's works. All couplings shall be fully checked for alignment and all necessary equipment for checking alignment shall be supplied by the Contractor.

Particular attention shall be paid to achieving accurate alignment of solidly bolted couplings and the Contractor's proposed alignment procedure shall be to the approval of the Supervisor. In particular, alignment procedures which involve rotating only one half coupling will not be accepted. The coupling alignment procedure shall include a final check in the "bolted-up" condition for "cranking".

Where flexible couplings are used, the Contractor shall fully describe the arrangements pro-posed for ensuring that the desired freedom of relative movement between the shafts is obtained, when transmitting a torque corresponding to the continuous maximum rating. Final alignment shall be checked by the Contractor in the presence of the Engineer.

8.3.2.4 Mounting

The Contractor shall ensure that the positions of foundations for machinery plinths, holding–down bolts and the setting of machinery are positioned in accordance with the approved machinery drawings.

The Contractor shall, upon receipt of the necessary approved drawings for the machinery, carry out excavation work and the construction of all the necessary foundations and bases for the various items of plant, including the forming of holes and chases for pipework, steel-works, cabling, conduit, rag bolts and where necessary, the building in of foundation bolts and sundry items of plant, all in accordance with the drawings. Spaces shall be left between the concrete and bedplates etc. for grouting and building in. The Contractor shall provide all necessary templates for fixing the positions of bolt holes, etc.

The machinery shall be mounted on flat steel packing of thickness selected to take up variations in level of the concrete foundations. The packing shall be bedded by chipping or grinding of the concrete surface. One packing only of selected thickness shall be used at each location which shall be adjacent to each holding down bolt. The number of shims shall not exceed two at each location and the thickness of each shim shall not exceed 3mm.

The machinery shall be aligned, levelled and pulled down by nuts of the holding down bolts with a spanner of normal length. Only grouting of holding down bolts to the approval of the Engineer shall be carried out before the machinery has been run and checked by the Supervisor for stability and lack of vibration. Final grouting of shims, etc., shall be carried out only after the aforementioned run and check by the Engineer has been completed, approval given, and the grouting area clean and suitable in every way.

8.3.2.5 Alignment

Where separate items of interconnected plant, such as motors, couplings, gearboxes and similar items depend upon correct alignment for satisfactory operation, then each and every item shall be positively located in it's correct operational position by means of dowels, locating pins, fitted bolts or other approved means to ensure that correct realignment can be easily achieved when reassembling the items after removal for overhaul.

8.3.2.6 Machinery finish

All covers, flanges and joints shall be clean, properly faced, bored, fitted, hollowed, moulded or chamfered as the case may be, according to the approved practice and all working plant and other apparatus shall in like manner be well and accurately fitted, finished, fixed and adjusted.

8.3.2.7 Lubrication

All bushes and ball or roller bearings shall be arranged for grease gun lubrication. Grease nipples shall be standardised. Provision shall be made in the design to prevent the over-lubrication of any part. It is preferable that routine lubrication of the plant shall be kept to a minimum.

Grease lubrication systems shall preferably be of the pressure type designed so that adjustment or recharging is not required more than once per nine days under normal operating conditions. Grease application points shall be easily accessible and, where needed, extension piping shall be provided. When a number of such points can be grouped, they shall be brought to a rigidly constructed battery plate and each point shall be clearly labelled. A permanently labelled grease gun shall be supplied for each type of grease required and each standard type of nipple fitted.

Oil lubrication shall preferably be of the re-circulating reservoir type, which automatically maintains the correct oil level and shall be designed for continuous normal operation for long periods. Sight glass level indicators shall be fitted on all oil reservoirs and the levels shall be easily read over the maximum operating range. Re-circulating oil lubrication systems shall be provided with an external replaceable filter element.

The level indicators shall be simple to dismantle for cleaning, clearly marked, with the mini-mum, normal and maximum oil levels at normal running temperatures and shall show the normal filling level at design ambient temperature. The sight glass shall be positively pro-tected against mechanical damage. Particular care shall be taken in arranging lubrication points to protect the works and the process water from accidental contamination. Catch trays, drip trays, screens and the like shall be generously provided throughout the works.

The type of lubricants and intervals of lubrication for each individual item of plant shall be entered on a working schedule, which shall form part of the operating and maintenance instructions. A complete schedule of recommended lubricants with their trade names, their purposes, viscosity, etc., container size and life and the name of the manufacturer (preferably one only) and his local supplier shall be stated in the Tender and is subject to written approval of the Engineer. The number of different lubricants shall be kept as small as possible.

Unless otherwise stated, the first oil or grease filling for bearings, transformers, etc., including the necessary quantity for flushing and for the first oil change, shall be included in the Tender Price.

8.3.3 Pumps

8.3.3.1 General requirements

These rules and regulations define the requirements for single and multi-stage centrifugal pumps or units with axial, semi-axial and radial flow, and for submersible pumps with electric motors.

Pumps shall be capable of satisfying the performance requirements as specified; be quiet in operation and free from vibration.

Pumps shall be mounted on base plates or suction stools manufactured of cast iron or steel plate. The pumps shall be accurately aligned and fixed by dowels or machined spigots. Holes shall be provided in the base plates or stools for foundation bolts.

Production of pumps shall conform to current standards such as ISO 9905, ISO 5199 and ISO 9908, and IEC standards (International Electrical Conditions). Pumps shall be driven by electric motors.

A label made of non-deteriorating material shall be attached to each pump and motor in a place where it can be easily read and shall show the following information:

- Serial number of the pump/motor and type
- Nominal flow in m^3/h
- Manometric head in m
- Net positive suction head (NPSH) in m
- Power consumption, voltage, start-up mode
- Number of rotations per minute

Pumps shall withstand continuous operation at full load (8000 hours/year).

Pump and impeller shall be designed in such a way that the duty point at nominal flow can be set as near as possible to the maximum efficiency point rate. The duty point(s) shall be guar-anteed according to ISO 9906 Class 1. If one or several pumps are installed in parallel the characteristics of the manometric lift depending on flow shall be perfectly identical.

The maximum output of the pump shall be related to the maximum nominal performance of the motor.

The regime of the pump shall be stable up to 130% of the nominal flow and the characteristic curve shall be sufficiently inclined.

Pump and motor material shall be suitable for the water they transport (aggressiveness, abrasion, impellers and comply with detailed regulations. Ambient temperature and pumped water temperature will not exceed the condition as indicated in the Particular Specifications.

8.3.3.2 Construction Elements

8.3.3.2.1 Standard centrifugal pump

Pumps shall be standardised single stage volute casing low pressure pumps according to EN 773, for horizontal installation, rotating part statically and dynamically balanced, with bearing bracket in back pull-out design. Bearings shall be grease-lubricated, maintenance-free, deep groove ball

bearings, sealed for life, shaft seal shall be uncooled soft-packed stuffing box packing, suitable for potable water, asbestos-free, flanges drilled to ISO 7005/2 (DIN 2501).

8.3.3.2.2 Motor

Motors shall have 2 or 4-pole rotors; motors between 1.1 kW and 90 kW and shall comply to CEMEP Voluntary Agreement (European Committee of Manufacturers of Electrical Machines and Power Electronics) and / or EPACT (Energy Policy Act, USA) requirements for energy saving, be squirrel cage induction motors, efficiency class EFF1 "high efficiency", and bear the corresponding values on the rating plate, protection class IP 55 (TEFC) and IK 08 for mechanical protection, continuous duty class S1, basic design, normal rated output for ambient temperature up to 40°C at altitudes up to 1,000 m above sea level, de-rating at higher altitudes. Larger electric motors shall be similar to the "high efficiency" motors, the efficiency at 4/4-load has to be at least 95.0% for ratings above 90 kW and below 200 kW, and has to be at least 95.5% for ratings of 200 kW and above. Thermal class shall be according to International IEC and EN standard, fabricated to ISO 9001 quality standard, electrical standards IEC 60034, IEC 60038 and IEC 60085, and mechanical standards IEC 60072 and IEC 60034, dynamic balancing to ISO 8821. However, all motors shall be designed acc. to thermal class F, but the temperature rise shall be allowed to class B only, allowing a service factor of 1.15. Permissible temperature rise to IEC 34-1.

Rated voltage shall be 400 Volts +5/- 20%, exceeding IEC 60038 standard, winding 400 V / 690 Volt Y, frequency 50 Hertz.

Number of starts shall be not less than 5 per hour, 3 minutes between restart.

8.3.3.2.3 Scope of supply of a standard pump unit

•Pump and motor completely mounted, painted, c/w soft-packed stuffing box, with strong type plate of corrosion-resistant material properly secured to the casing
•Common base plate / base frame for pump and electric motor in torsion-resistant design, including foundation bolts and nuts

8.3.3.3 Materials

Materials of pump and motor shall be as follows:

- Volute casing: Grey cast iron JL 1040 (GG-25)
- Bearing bracket: Grey cast iron JL 1040 (GG-25)
- Discharge cover: Grey cast iron JL 1040 (GG-25)
- Impeller: Bronze CC480K-GS (G-CuSn10)
- Pump shaft: Steel C45 or chromium steel 1.4021
- Wear rings: Bronze CC495K-GS (G-CuPb10Sn) or equivalent
- Shaft protecting sleeves: Stainless steel 1.4122 or equivalent
- Outside coating: after surface treatment, 2-pack zinc-rich primer and top coat of epoxy resin with a layer thickness of not less than 100 micron in ultramarine blue
- Inside coating: after surface treatment, 2-pack zinc-rich primer and top coat of epoxy resin with a layer thickness of not less than 125 micron in black

8.3.3.4 Accessories

All necessary accessories as specified below shall be provided by the Contractor:

- Flexible coupling with spacer sleeve allowing dismantling of impeller without loosening of pipework or motor
- Coupling guard as per EN 294
- Flushing / sealing water pipe
- Pressure gauges of CrNi-steel, 0 to 10 / 16 bar at discharge, –1 to 1.5 bar at suction side, muting, cocks, vents
- Drain, horizontal
- Spare parts for 5 years' service for the pump and the electric motor

8.3.3.5 Packing and Shipment

Unless stated otherwise in the specifications, the pump unit shall be supplied completely assembled and mounted on the common base plate / base frame in a strong and suitable case / crate / wooden box suitable for shipment to the place of ultimate installation.

8.3.4 Vessels

All vessels shall be designed in accordance with the applicable international standards and regulations.

The Contractor is held responsible for the correct design and dimensioning of the apparatus.

Connections shall be provided for all pipe work, together with connection and tapping points for instrumentation. Manholes, vents, drains, safety devices and any platforms necessary for safe operation and easy maintenance have to be included in design and supply.

If under any operation conditions vacuum can occur in the vessels, they shall be designed for maximum pressure and full (= 100%) vacuum.

The welding factor for all vessels is fixed to v = 1.0. The minimum wall thickness should not be less than 7 mm, and an appropriate corrosion allowance based upon the particular mate-rial, but not less then 1 mm.

Instrumentation and control equipment shall be provided according to the safe service requirements. A minimum requirement is to equip each vessel with a local level indicator and/or a pressure indicator and if applicable a temperature indicator.

Manholes shall be provided as follows:

•Manhole (minimum nominal bore 600 mm) for vessels of 1.0 meter diameter and above
•Hand holes (minimum size 200 mm) for vessels below 1.0 meter diameter.

All nozzles shall be provided with flanges and shall be so arranged that practical pipe connections are possible. The stub length for all stub pipes shall be at least 200 mm, measured from the tank wall to the flange sealing surface. In the case of insulated vessels, the length shall be chosen so that there will be a clear space of at least 100 mm between the cover of the insulation and the underside of the flange. Nozzles of nominal bore DN 50 and less shall be reinforced by two ribs at different planes.

Nozzles shall not have a diameter less than DN 25.

For insulated vessels, provisions must be made for fixing and supporting the insulation.

Manhole covers of nominal weight more than 20 kg shall be provided with hinged arms.

All tank internals must be replaceable through the manhole. Prefabricated vessels must as a minimum have a coat of primer applied before transport. They shall be cleaned and internally dry. All openings must be secured closed before transport.

8.3.5 Air blowers and compressors

The air compressor units shall include air cooled compressors, motors, pressure switches, gauges with pressure snubbers and isolating cocks, pressure tanks with handholes, relief valves, drain cocks from tanks with pipe taken to nearest gully, line pressure regulators, oil separators and all other necessary controls, pipework, etc.

The compressors shall have suction filters, suction and discharge silencers and be mounted on vibration isolators on a common rigid mild steel base plate on top of the receiver. The pipework connections to the compressors shall be flexible to avoid vibrations being transferred to the pipes or to any structures.

The compressors shall be manufactured in accordance with the respective EN and DIN standards and specifications for design and construction of reciprocating type compressors. The acceptance tests for the compressors shall be carried out in accordance with ISO 1217, Methods for simplified acceptance testing of air compressors.

The receiver shall have a volume of 350 litre. The capacity of the compressor shall be 900 litre per minute at a maximum pressure of 8 bar.

8.3.6 Drainage pumps

A drainage pump shall be installed at each pumping station with a floor below the surrounding ground level. The pumps shall be placed in a sump in the pumping station.

Each pump shall be of the submersible type with a capacity of approximately 3 l/s at a head of 5.0 m. Pump and motor units shall be continuously rated. All components shall be capable of renovation during overhaul, all replaceable components shall be readily available.

The motor and the pump shall form a complete integral unit suitable for operation in a sub-merged condition. The stator casing, pump housing, impeller and discharge connection shall be manufactured of cast iron. The pump shaft shall be made from stainless steel.

The pump shall be equipped with a complete level control system with automatic start and stop of the pump. The discharge pipe, of same diameter as the pump discharge, shall be included and routed to the nearest pump sump. The pipe shall be galvanised steel and further protected outside with two layers of bitumen.

8.3.7 Power Generators

8.3.7.1 General

The power generating system shall supply electrical prime power to the plant as required to maintain basic system functions in the case of shut-down of grid. It shall consist of one generating set, operated by a diesel engine driving a 3-phase synchronous alternator with 1500 rpm. The rating of the generating set shall be in accordance with the power requirements to maintain the basic function of the plant and to provide lighting.

Prime Power shall be available for an unlimited number of annual operating hours in variable load applications, in accordance with ISO 8528-1. A 10% overload capability is available for a period of 1 hour within 12-hour period of operation, in accordance with ISO 3046-1.

The standby power rating shall be applicable for supplying emergency power in variable load applications in accordance with ISO 8528-1. Overload is not allowed.

The power generator shall fulfil the following standard features:

- Water cooled diesel engine
- Oil and fuel filter fitted, water separator
- Electric starter and charge alternator 24V DC
- Lube-oil drain valve
- Normal dirty air filter
- Single bearing alternator, class H/H, IP23
- Anti vibration mounts
- Single sheet metal fuel tank, capacity of 8 hours
- 70% standby load
- Welded steel base frame with A/V mounting
- Set mounted starting battery
- Standard voltage 400/230 V, 50 Hz
- Loose silencer
- Low fuel level shutdown
- Exhaust silencer – Industrial (9dB), in line
- Flexible and fixing kit for industrial silencer
- Warranty – 5 years extended standby Application
- Battery charger
- Packing export box
- Heavy duty air filter
- Oil temperature shutdown

8.3.7.2 Engine

The diesel engine shall fulfil the following requirements:

- Operation method: four-stroke cycle, turbocharger
- Combustion method: direct fuel injection
- Valves per cylinder: two valves per cylinder
- Engine mounting: resilient to base skid
- Starter Battery voltage: 24 VDC

- Air cleaner: Dry element and restriction indicator
- Governor: Electronic
- Exhaust System: Exhaust temperature 565°C [1049°F]
- Max back pressure: 750mm CE [30in. WG]
- Fuel System complete, pump, filter, line from tank,
- Oil System complete, pump, filter
- Air intake heavy duty filter
- Coolant System: Max water temperature 105°C
- Outlet water temperature 93°C
- Electric fan
- Permissible restriction on air flow: 20mm CE [0.8in. WG]
- Type of coolant: Gencool
- Thermostat 82-94 °C

The engine shall be rated for continuous operation. Radiation heat shall not be higher than 3-4% of the engine rated power. All components of the engine shall be free of asbestos. The engine must be suitable for running with fuel of high sulphur content. The engine has to be painted with two coats of alkyd-resin paints, colour as instructed by the Engineer. Data and instruction plates shall be written in English.

8.3.7.3 Alternator

The alternator shall be a 3-phase, synchronous, brushless single bearing, self-exciting, self-ventilating alternator with damping equipment for unbalanced load up to 30%.

The alternator shall be operated star connected. Both ends of each winding have to be brought out to terminals in the alternator's terminal box. Each terminal shall be equipped with a suitable current transformer for differential protection and over current/short circuit protection. At the outgoing terminal of the current transformer auxiliary busbars to connect the power cables have to be installed. The size of the alternator's terminal boxes shall be sufficient to allow maintenance work and refastening of all bolt connections without hindrance or requirement for special tools. The alternator shall be delivered with the correct star-point re-actor, which shall be installed in the alternator's switchgear cabinet.

The Contractor shall note that the generator must be suitable to be switched to the unloaded transformer in case of power failure. In this situation, initially high currents may be required to demagnetise the transformer. The windings and the mechanical components of the genera-tor have to be manufactured to these criteria.

The characteristics of the alternator shall be as follows:

- Voltage: 400/230 V
- Frequency: 50 Hz
- Speed: 1500 rpm
- Site rating: according basic operation needs
- Degree of protection: IP 65
- Insulation class: F, tropicalised with anti-humidity insulation
- Setpoint adjustment: +/- 5%
- Cooling air temperature: 45°C
- Fully interconnected damper winding

- AC exciter and rotating rectifying unit
- Epoxy coated stator winding
- Rotor and exciter impregnated with tropical grade insulating oil and acid resisting polyester resin.

8.3.7.4 Control panel

The following functions shall be available for monitoring, and protecting the generator set:

- Frequency meter, Ammeter, Voltmeter
- Alarms and faults low Oil pressure, high water temperature,
- Over crank, overspeed (>60 kVA), Min/max alternator,
- Low fuel level, Emergency stop.
- Engine parameters Hours counter, Engine speed,
- Battery voltage, Fuel level, Air preheating
- Anti condensation heater
- Heat shield protection •
- Enforced impregnation

Unless stated otherwise the generating set shall be delivered with all required fuel, cooling, air and exhaust systems, the required instrumentation for operation control, all genset accessories required for appropriate maintenance and testing (tool and test kits) and spare parts for one year operation.

8.3.8 Valves, penstocks and actuators

8.3.8.1 General

All valves and sluice gates shall be best water works quality and suitable for use with water or water works sludge at all temperatures up to 45°C. Valve parts to be in contract with potable water shall meet the relevant provisions of EN standards. Small valves and gates shall conform to DIN 3230-4.

Generally, valves shall be leak-proof in either flow direction except for check (non-return) valves, when the nominal pressure is applied. All valves with design pressures larger than PN 10 and larger than DN 100 shall be workshop-tested to DIN 3230 for tightness and soundness of materials. All pressure reduction valves, safety valves and similar components shall be workshop-tested and provided with a works certificate.

Valve bodies shall bear the following information:

- Manufacturer's name,
- Hydraulic test pressure,
- Size of valve,
- Flow-direction arrow.

The operating gear of valves and sluice gates shall be such that one man can open and close the valve against an unbalanced head 15% in excess of the maximum to be encountered in service. Where necessary, arrangements shall be provided with gearing to achieve this requirement. The maximum couple which can be exerted by one man shall be taken as 130 N, and the maximum

force as 250 N. Where specified, valves 300mm nominal bore and over shall be fitted with bypasses with isolating valves. Valves above 250 DN shall be complete with a spur gear unit.

Gate valves shall be provided with renewable seats and it shall be possible to remove the gates without removing the valve body from the pipe work. The operation of all valves shall be such that turning the hand wheel or tee-key in a clockwise direction closes the valves.

All materials shall comply with the appropriate EN or DIN standards and shall be subject to the Engineer's approval. All castings shall be free of blowholes and other defects.

Gate valves and butterfly valves shall be suitable for flow in either direction.

All standard valves shall be suitable for frequent operation and for infrequent operation after long periods in the open or closed condition. Packed glands shall be arranged for easy re-placement of the packing, which shall be accessible without removal of the valve from the pipe. Precautions shall be taken to prevent corrosion of the valve spindles in contact with the gland packing.

Each valve or sluice gate or its operating equipment shall bear an approved brass nameplate stating it's function in English. Valves, cocks and operating spindles which are for submerged operation, shall be independent of external lubrication.

8.3.8.2 Spindle operation

Unless otherwise specified, all valves shall be located and orientated in readily accessible positions with hand wheels conveniently arranged for ease of operation. Where this requirement is impracticable or would lead to undue complication in the works, operating spindles shall be taken vertically to penstocks for manual operation.

Chain operated wheels shall not be incorporated in the arrangements. Knuckling of spindle extensions and remote operation through mitre geared linkages shall be avoided wherever possible.

Tee-key operation of valves and sluice gates shall not be adopted unless so specified. Where so provided, the spindles shall be fitted with a cast iron detachable cap manufactured to and of identical shape to the valve spindle caps dimensioned in DIN 4056.

Sluice gates and valves of 50mm nominal bore and over shall be fitted with mechanical position indicators to show the amount which the valve or penstock gate is open or closed in relation to its full travel.

8.3.8.3 Hand wheels

Operating hand wheels for gate valves and penstocks shall be cast iron. All hand wheels on valves over 50mm diameter shall be fitted with a circular inscribed brass disc with an arrow indicating the clockwise direction of closing and the word "CLOSE" in English. Plates on hand wheels for valves over 150 mm diameter shall, in addition, have a simple inscription denoting the function, e.g. "Inlet".

External hand wheels shall be fitted with a purpose made integral locking device to prevent operation by unauthorised persons. A padlock and chain will not be acceptable.

8.3.8.4 Materials of valves and penstocks

For the various valves types the following materials shall be used:

8.3.8.4.1 Gate Valves: refer to 6.3.2

8.3.8.4.2 Butterfly Valves: refer to6.3.3

8.3.8.4.3 Air Valves: refer to:6.3.4

8.3.8.4.4 Check Valves:

body cast iron with lamellar graphite
inside shaft stainless steel AISI 410
body and door seat stainless steel

8.3.8.4.5 Float Valves:

Body Cast iron with guide brass
Valve seal Soft seal on metal
Piston seal Guide ring brass / O-ring seal
Float lever Welded steel
Float ball Copper sheet, tinned or stainless steel

8.3.8.4.6 Sluice Gates (penstocks):

Frame, gate guide rails Cast iron GG20
Threaded stem X12 Cr Mo 517 ISO metric trapezoidal single acme thread
Stem extension Steel St 50-2
Stem nut Bronze acc. EN 1982
Gate and frame clamps Cast iron, GG20
Gate sealing face Sewage and sea water resistant, finished
Frame sealing-face Cast iron, finished round sealing ring
Seal between wall and frame Cast iron, finished round sealing ring

8.3.8.5 Gate valves: refer to 6.3.2

8.3.8.6 Check valves

Check valves shall be double flanged conforming to EN 12334.

They shall be of the quick acting non-slam single or multi door type designed to minimise slam on closure. The valves shall be fitted with renewable door sealing faces which shall be positively fixed.

All check valves shall be suitable for operating in the horizontal plane unless otherwise specified. Covers shall be provided to allow ample access for cleaning and service and shall be supplied complete with tapped bosses fitted with air release cocks.

Non-return valves on main pump delivery branches shall be of the internal damper type and shall achieve the largest possible closing angle before the water column returns. The free swing motion

of the tilting disc shall be assured for the closing stroke until approximately 10% before the closed end position is reached. The last 10% of the closing stroke shall be damped.

Materials used in the manufacture of the check valves shall be as specified above.

8.3.8.7 Butterfly valves refer to6.3.3

8.3.8.8 Flap valves

Flap valves shall be round or rectangular, single door bitumen coated, double hung tidal type flap valves, with the clear opening dimensions designed to pass the required discharge. Flap valves shall be fitted with phosphate or bronze or stainless steel or similar approved corrosion-resistant metal faces and hinge pins and shall have a galvanised mild steel lifting eye.

Flap valves shall be designed to withstand a working pressure equivalent to 8.0m of water and shall be tested after installation with a feeler gauge to a non-acceptance of 0.05mm be-tween sealing faces when closed.

Materials used in the manufacture of the flap valves shall be as specified above.

8.3.8.9 Sluice gates

Sluice gates shall be of the rising spindle type conforming to the relevant DIN or EN Standards.

The frame and guide shall be in one piece cast construction or with the guides doweled and bolted to the frame. Frames shall incorporate a rectangular or circular opening with integral spigot on the back. The gate shall be of one piece cast construction with vertical and horizontal ribs, a reinforced pocket to receive a gunmetal thrust nut, pads to receive wedges and reinforced periphery around the backside.

Guide rails shall be of such length as to retain at least one half of the vertical height of the slide when in the fully open position. Grooves running the full length of the guide rail shall be accurately matched to receive slide tongues.

The manufacture and assembly shall be such as to ensure accuracy in making the frame and door faces and tight closure while maintaining freedom of gate movement during operation and minimising sliding wear of the sealing faces. They shall incorporate adjustable wedges or swivelling cams and actuating pegs manufactured from a corrosion-resistant material.

Metal sealing faces of the frame and gate shall be sewage and sea water resistant and finished. Unless otherwise stated each sluice gate shall be provided with a suitable hand wheel of adequate diameter for the duty required, or gearing shall be supplied, where necessary, to ensure that the required operating force applied by hand to the rim of the wheel or geared handle does not exceed 250 N.

Gearboxes or hand wheels shall have cast on them, the direction of closing which shall be clockwise and vandal and weather-proof covers shall be securely fitted to protect the threads of rising spindles. Each tube shall be clearly and permanently engraved to indicate the position of the penstock to which it is fitted. Spindles shall have machine cut robust trapezoidal form threads. Extension spindle couplings shall be of the muff type and they shall be drilled and provided with

a nut and bolt for securing the spindle to the penstock spindle head which shall likewise be drilled to receive the bolt.

Where sluice gates are specifically required to be operated by tee-keys, spindle caps of the specified type shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle which shall also be drilled. All hand wheels, penstocks, foot brackets and guide brackets shall be of cast iron. Guide brackets shall be adjustable.

All sluice gates shall be delivered with a temporarily attached template in order to facilitate accurate installation of the frame and fittings.

8.3.8.10 Air / gas relief valves refer to 6.3.4 :

8.3.8.11 Pressure control valves

Pressure control valves of DN 80 diameter and above used for pressure reduction, pressure sustaining or pressure relief shall be of the double flanged type and shall operate by use of an integral auxiliary pilot circuit suit able for the fluid. For DN less than DN80 diameter a direct spring controlled valve may be used.

The valves shall be adequately sized to control the flow and pressure differential required for the application with an accuracy of ± 2.5% of the set value. They shall be capable of operating at a sustained pressure 20% in excess of the nominal declared working pressure. Valves shall be sized to ensure that their full capacity will be more than adequate to accept the de-sired maximum flow at the minimum required differential pressure.

The main pressure control valve operation shall be actuated by a hydraulic differential pressure system in balance with a spring loaded bellows type diaphragm, the reference pressure being bled from the inlet and outlet of the main valve. The diaphragm spring shall be adjust-able by a screw to cover the range of pressure adjustment specified for the valve application.
The control circuit bleeds shall be controlled by isolating cocks to enable the system connections to be removed without disturbing the main valve.

The detail connections and application of reference pressure shall be arranged to suit the requirement, whether for pressure reduction, pressure relief, to sustain a constant pressure, or regulate flows. Monitoring orifices shall be protected suitably by fine mesh strainers on the pipeline side, the elements, strainers, pipe work and fittings being in suitable corrosion-resistant materials.

A pressure gauge shall be fitted to indicate the regulated pressure. Where required, a needle valve shall be incorporated in the connection from the relay valve to the main valve piston cylinder to adjust the valve setting. When the main relay valves are closed, the main valve seating shall be "drop tight" under the inherent hydraulic pressure.

Materials used in the manufacture of the pressure control valves shall be as specified above.

8.3.8.12 Penstocks

8.3.8.12.1 General Requirements

Penstocks shall be of the following types:

- Cast iron with scraped non-ferrous sealing
- Cast iron with rubber sealing faces
- Stainless Steel

The type and size of penstock to be used in any particular location shall be as indicated on the Contract Drawings.

The frames, doors, sealing faces and spindles of each type of penstock shall be as specified in the appropriate clauses herein. Unless otherwise stated, each penstock shall be provided with a suitable hand wheel of adequate diameter for the duty required and gearing shall be supplied where necessary to ensure that the required operating force applied by hand to the rim of the wheel does not exceed 250 N. The height of the hand wheel shall be approximately 1.0 m above operating level, unless otherwise stated.

Hand wheels shall have cast on them, the direction of closing which shall be clockwise. Vandal and weatherproof clear polycarbonate tube covers shall be securely fitted to protect the threads of rising spindles. Each tube shall be clearly and permanently engraved to indicate the position of the penstock.

Spindles shall have machine cut robust trapezoidal or square form threads. They shall be of stainless steel or manganese steel or manganese bronze. Extension spindle couplings shall be of the "muff" type and they shall be drilled and provided with a nut and bolt for securing the spindle to the penstock spindle head, which shall likewise be drilled to receive the bolt.

Where extended spindles installations require to be operated at elevated floor level, spindle guides or guide brackets shall be provided close to the floor level. The maximum distance between spindle guides must not exceed 2.5 m.

Where penstocks are required to be operated by tee keys, spindle caps shall be fitted. The caps shall be drilled and each provided with nut and bolt for securing to the spindle, which shall also be drilled. Where caps are fitted, they shall each be supplied complete with operating tee key. All hand wheels, penstocks, foot brackets and guide brackets shall be of cast iron. Thrust tubes shall be cast iron.

All penstocks shall be provided with hand wheels or motor driven gears. For penstocks of 300 mm (square or circular) and above and for all motorised and actuator operated pen-stocks, unless otherwise stated, thrust tubes shall be provided between the penstock frame and the headstock, in order to absorb the operating thrust in both directions. Thrust tubes shall incorporate all necessary fixing brackets and spindle guide plates.

Headstocks and foot brackets shall be provided where the latter are specifically called for. Guide brackets shall be provided where necessary. The spindles shall be fitted with thrust collars and arranged so as to transmit the thrust arising from operation of the penstock directly to the penstock frame. Where headstocks are required they shall incorporate a penstock position indicator.

Penstocks shall be water-tight under the conditions of head and direction of flow as stated in the appropriate Clause or Schedule of the Particular Specification and/or the Contract Drawings.

8.3.8.12.2 Cast Iron Penstocks

The frames and doors of cast iron penstocks shall be made from close grained grey iron. The penstocks shall be designed so as to ensure tight closure while maintaining freedom of door movement during operation and minimising sliding wear of the sealing faces. They shall incorporate adjustable wedges or swivelling cams and actuating pegs manufactured from a corrosion resistant material.

Non-ferrous metal sealing faces shall be formed from accurately machined gunmetal or bronze strips bedded and fixed to machined recesses by corrosion resistant countersunk screws. The faces of the strips shall then be brought together in the operating position and hand scraped to a watertight finish.

Rubber sealing faces shall be formed from high quality synthetic rubber suitably shaped to interlock into grooves in the frame or door and shall be securely bonded thereto. The nut in the door shall be gunmetal.

8.3.8.12.3 Stainless Steel Penstocks

Framework, guides and thresholds shall be of stainless steel according to Grade AISI 316L.

The penstock blades shall be made of stainless steel and the spindles shall be made of stainless steel of a quality Cr 25%, Ni 4.5%, Mo 1.3% type, as AISI 329 or similar. The metal sealing faces shall be formed from accurately machined gunmetal or bronze strips. The nut in the penstock blades with non-rising spindle shall be of gunmetal.

8.3.8.12.4 Hand operated rising spindle penstocks

Hand operated rising penstocks shall be purpose made spindle enclosing pedestal pillars manufactured in close grained cast iron, either of the hand wheel or the single or double gear crank operated type. Lift nuts shall be in cast bronze threaded to fit the rising stem.

Spindle thrusts shall be taken on ball or roller bearings provided above and below the flange on the lift nut and designed to take five times the maximum thrust developed in opening and closing the gate.

Gears shall be of cast bronze, accurately machined with cut teeth, and smooth running with similar shafts in bronze sleeve bearings or roller bearings of ample size. The gearbox shall be covered by a removable flanged cast iron cover dome. All gears and bearings shall be enclosed in the cast iron housing. Fittings shall be provided so that all gears and bearings can be periodically lubricated. The removable cast iron crank shall be fitted with a brass rotating handle, set with its axis approximately 0.8 m above ground or floor level. The maxi-mum crank radius shall be 250 mm, the effort required less than 250 N and the direction of rotation clockwise to close. The direction of opening shall be marked and annotated on the penstock casting.

The rising stem unit shall be provided with spindle cover of sufficient diameter and length to permit full travel of the threaded stem without obstruction. The top of the stem shall be capped and the bottom flanged to suit the housing or adapter plate. Each penstock shall be provided with a brass position indicator to show the position of the gate at all times. Indication shall be in the support stem through a brass faced and calibrated slot.

Penstocks shall be vertical. All mountings shall be through a rigid rectangular plate with at least 4 fixing holes. Base fixings shall be designed for the peak thrust with a factor of safety of 5. The design thrust shall be stated on the Contractor's drawings.

8.3.8.12.5 Hand operated non-rising spindle penstocks

Non-rising spindle penstocks for valves shall be purpose made vertical spindle enclosing pedestal pillars, fitted with a valve position indicator mechanism, hand wheel and suitably fit-ted with robust bearings and bushes, and suitable for prolonged external exposure.

All mountings shall be through a rigid rectangular base plate with at least 4 fixing holes. Hand wheels shall be horizontal, approximately 0.8m above ground or floor level.

8.3.8.13 Venturi Meters

Venturi meters shall comprise following elements:

Venturi pipe to ten pressure rating of the pipe,
Design conforming to DIN 1952 short length. Body of grey cast ting chamber of brass or of grey cast. Maximum differential pressure: 0.25 bar.

Connecting pipes including drain valves and ventilation valves of globe valve type,

Mechanical flow indicator, scale indicating 1 l/s max 500 l/s, linear, at rated differential pressure of 0.25 bar. Mercury gauge for differential pressure. Indicator suitable for incorporation of an integrating meter for 6 digits to be powered by a synchtonous motor. Material ap proved synthetics, stainless steel.

8.3.8.14 Electric actuators

Where required penstocks and valves shall be operated by means of electrically driven actuators with integral reversing starters.

Each actuator shall be fully weatherproof and fitted with anti-condensation heater, upper and lower limit switches and torque switches. All local controls shall be protected by a lockable cover.

The electrical supply available is 380 volts, 3 phases, 4 wire 50 Hz, and the unit shall incorporate a 380/220 to 110 volts transformer for control circuits.

Each actuator shall be adequately sized to suit the application and be continuously rated to suit the modulating control required. The operating gear of all penstocks shall be capable of opening or closing the gate against an unbalanced head equal to the maximum working pressure.

The gearbox shall be oil or grease filled, and capable of installation in any position. Alterna-tive hand operation shall be possible, and the hand wheel together with a suitable reduction gearbox if necessary, shall be of adequate dimensions for easy operation by two men. The motor drive shall be automatically disengaged when under manual operation. Hand wheels shall be rotated clockwise to close the valves, and shall be clearly marked with the words “OPEN” and “CLOSE” and arrows in the appropriate directions. The rims of hand wheels shall have a smooth finish.

All actuators with the exception of rising spindle penstocks shall be equipped with indicators showing whether the penstock is fully open or closed. A transparent PVC cover shall be fit-ted to protect the thread of the rising spindle. All operating spindles, gears and penstocks shall be provided with adequate points for lubrication.

8.3.8.15 Support of pipework and valves

All necessary supports including structural steelworks, foundations, hangers, saddles, sliding shoes, slings, expansion pieces, fixing bolts, foundation bolts, fixing and anchor points and all other attachments shall be supplied to support the pipework and its associated equipment in an approved manner. Valves, meters, strainers and other devices mounted in the pipe-work shall be supported independently of the pipes to which they connect.

Wherever possible flexible joints shall be provided with tie-bolts or other means to transfer longitudinal thrusts along the pipework as a whole so that the external anchorage at blank ends, tees and valves may be kept to a minimum. The Contractor shall indicate on his working drawing what thrust blocks are required to anchor pipework supplied by him.

All brackets or other supports which can conveniently be so designed, shall be rigidly built up of steel sections by riveting or welding, in preference to the use of castings. No point of passage of pipes through floors or walls shall be used as a point of support, except with the approval of the Engineer.

8.3.8.16 Hand stops

Hand stops shall have cast iron frames with galvanised mild steel doors or alternatively made of stainless steel. Hand stops shall be suitable for channel or wall mounting according to the installation requirements.

Hand stop doors shall be provided with hand-slots to facilitate operation and a peg or chain shall be provided to hold the door in the open position. Pegs or chains shall be of stainless steel or galvanised mild steel.

On deep channels or where specified, hand stop doors shall be provided with lifting handles. Lifting handles shall be of identical material to the doors and guide/retaining brackets shall be provided. All materials used in the manufacture of hand stops shall conform to the requirements for penstocks specified herein.

8.3.8.17 Pressure and vacuum gauges

Gauges shall be provided for all pumps on the pressure side and on blowers on the suction and pressure side or as shown on the Drawings and for all other equipment where necessary.

Pressure and compound gauges of approved manufacture with an accuracy of ± 2% shall be provided and fixed directly to and at the same level as the delivery and suction branches of each dry well pump. The gauges shall be fitted with diaphragm type isolating valves and with siphon pipes. Gauges shall not be connected to air release or auxiliary suction pipes.

All gauges shall have concentric dials of 150 mm in diameter, pressure gauges being graduated in metres head, and compound gauges in cm of mercury and metres head. Gauge graduations shall be such that the gauge is never used continuously beyond 60 per cent of the maximum graduation.

The face of the dial shall have a warning label marked in red attached thereto reading in Swahili: "IMPORTANT: CLOSE WHEN NOT IN USE".

The gauge mechanism shall be of the Bourdon tube type, having stainless steel movements and shall comply with EN 837-1. It shall be sealed from the liquid being measured by means of a diaphragm or capsule and be filled with silicone oil. All gauges shall be fitted with a pressure snubber to dampen pressure pulsations.

Before the gauges are delivered to site, each gauge shall be tested in accordance EN 837-1 and a test certificate for each gauge, confirming that they are of the required accuracy, shall be sent to the Engineer. Further copies of the test certificates shall be incorporated in the operating and maintenance manuals.

8.3.9 Pipework in Plant

8.3.9.1 General Requirements

All pipes and assembling parts selected under this Contract must be of first quality, truly circular, and of uniform thickness, free from scale, lamination, honeycombs and other defects, and shall be designed and suitable for the stated pressures and temperatures.

The Contractor shall include for the supply, delivery and erection of all pipework and fittings within the buildings. The pipework installation shall be so arranged, as to ease the dismantling and removal of pumps or other major items of equipment. Expansion and dismantling joints shall be of the sleeve type and be double flanged. Dismantling joints shall be able to withstand the total tension loads from the maximum pressure occurring in the pipes. The material shall be carbon steel and the coatings shall inside and outside be epoxy.

A flange adapter shall be included in the suction and delivery pipework of all pumps for easy dismantling and provision shall be made for flexible joint arrangement to structures. The adapter on the pump delivery shall be upstream of its respective check valve. Where the pump delivery pipework joins the pumping station manifold the entry shall be horizontal. The ends of pipes for use with flange adapters and couplings shall be faced, squared and sized to the tolerances required by the manufacturer of the coupling.

All loose flanges shall be secured to fixed flanges by suitable tie–bolts.

All pipework shall be adequately supported with purpose made fixings. When passing through walls, pipework shall incorporate a puddle flange.

Where the coating of the pipes is damaged, the surface shall be cleaned and dried and the Contractor shall paint the damaged area with a minimum of three coats of paint to the full thickness and specification as the original coating.

Flange adapters and unions shall be supplied and fitted in the pipework runs wherever nec-essary to permit the simple disconnection of flanges, valves and equipment without the need to disturb long runs to remove valves, equipment, etc. The final outlet connection of the pipework shall match the connecting point of the external rising main.

Flanged joints shall be made with 3 mm thick, full face, rubber gaskets, pierced to take the bolts, and the face of all flanges shall be machined to give a true angle of 90° to the centre line of the pipe or fitting. The whole of the jointing and materials necessary to fix and connect the pipe including adequate and efficient pipe supports shall be included in the Contract.

The hydraulic test pressure applied at the manufacturer's works shall be twice the working head, or one and a half times the maximum working head, whichever is the greater, unless otherwise specified. After completion of any fabrication, all pipes shall be hydraulically tested. If any alterations involving additional fabrication are made after dispatch, a further hydraulic test will be required on the pipe or piping assembly concerned.

The Contractor shall be responsible for ensuring that the internal surface of all pipework is thoroughly clean before and during erection and before commissioning. Cleaning shall include removal of all dirt, rust, scale and welding slag due to site welding. Before dispatch from the Contractor's works the ends of the pipes, branch pipes, etc. shall be suitably capped and covered to prevent any accumulation of dirt or damage. This protection shall not be re-moved until immediately prior to connecting adjacent pipes or valves. All small bore pipes shall be blown through with compressed air before connection is made to instruments and other equipment.

Unless otherwise specified, all pipe work shall be adequately sized to limit the velocity to a maximum of 2.5 m/s.

The Contractor shall note the necessity for providing flexibility in the pipework at joints in the main structures to allow for differential settlement and thermal stresses which will not be transferred to the anchor blocks. Flexible joints, collars and cut pipes shall be provided on all pipework where necessary to allow for some margin of error in the building work. The pipe-work system shall be so designed to ensure that anchorage at blank ends, bends, tees and valves are kept to a minimum. The Contractor shall indicate on his working drawings any thrust blocks that are required to anchor pipework supplied by him.

8.3.9.2 Ductile Cast Iron pipes

Refer to: 6.2.6.2

8.3.9.3 Steel pipes

Refer to: 6.2.6.3

8.3.9.4 Stainless steel pipes

All stainless steel in pipes and fittings shall be in accordance with Grade 316S31 to EN 10088 unless otherwise stated and stainless steel located in water shall be in accordance with Grade 316S13.

8.3.9.5 Polyethylene pipes

Refer to: 6.2.6.4

8.3.9.6 PVC Pipes

Refer to: 6.2.6.5

8.3.9.7 Fittings

Fittings, such as elbows, tees and reducers, shall be all factory made acc. to relevant standards.

8.3.9.8 Flanged Connections

Flanged connections shall, where not otherwise indicated, be lapped type joints with weld-on rings with necks and loose flanges. The bolt circle, number of bolts and bolt dimensions shall all be in accordance with DIN 2642. The weld-on rings and the necks shall be made of stainless steel as specified for the pipe material.

Loose flanges shall be made in accordance with DIN 2642. All loose flanges of steel shall be hot-dip galvanised in accordance with ISO 1461 with a minimum thickness of 80 microns.
Loose flanges located in water shall be made of stainless steel.

Bolts, nuts and washers shall be made of hot-dip galvanised steel with at least 55 microns of zinc in accordance with ISO 1461. Bolts and nuts shall comply with ISO 898 and be of at least property class 8.8. Washers shall be placed under both the nuts and the bolt heads.

Gaskets for flange joints shall be 3 mm thick, full face, rubber gaskets, pierced to take the bolts.

8.3.9.9 Joints

Before making any joint the Contractor shall ensure that the interior of each pipe or valve is clean and that it remains clean. Immediately before starting a joint the Contractor shall clean the end of each pipe to be jointed and shall otherwise specially prepare the ends for jointing as may be necessary for the particular kind of joint. All mechanical joints shall be cleaned and have their paintwork or coating made good before assembly

.

The Contractor shall use only the proper jointing parts as specified and obtained through the suppliers of pipes or valves. All joints shall be accurately made and shall be capable of passing tests for individual joints and for the completed pipeline.

After completing a joint any protective paint or other coating shall be made good, and any metal joint which is not already coated shall be cleaned and painted according to painting specifications, the Clause "Corrosion Protection". Internal lining and additional external protection of the joints shall be carried out as specified.

8.3.9.10 Drains and Vents

The Contractor shall be responsible for providing all the necessary facilities for the safe disposal of all matters arising from all drains and vents to the approval of the Engineer. All vents and drains shall be arranged to have a continuous rise or fall as appropriate to the point of disposal of the matter being discharged. Where practicable, vents shall terminate 2000 mm above roof level or as otherwise approved by the Engineer.

8.3.9.11 Installing pipes in and through structures

Steel structures, walkways, platforms, stairs and ladders over large diameter pipes with the upper pipe edge higher than 600mm above ground level shall be provided and the costs included in the Tender Price.

The installed piping shall be sloped to prevent trapping of air bubbles, unless relieved by air valves. The lowest point of a pipe sling shall be provided with a drain or flushing valve.

Adequate clearance shall be given to parallel pipes to allow for easy maintenance without disturbing other lines. All overhead piping shall have a minimum clearance of 2 m from operating floors and platforms. Generally pressurised pipes should not be embedded in concrete. When embedding such pipes, the approval of the Engineer is required.

Where pipes pass through a concrete wall or structure, they shall project from the external face(s) of the structure by 300 mm for pipes of DN 500 or less and by 500 mm for pipes in excess of DN 500, the surface of such pipes shall be prepared to the approval of the Supervisor to ensure a satisfactory bond between pipes and concrete.

The first pipe in open ground leaving a structure shall be a short length of either spigot and socket or double socket to suit the flow direction. The length of this pipe shall be one and a half times the nominal diameter or 600 mm whichever is greater.

Puddle flanged fittings for building into the walls may be of the single-flanged type or of the double-flanged type. Where the single-flanged type is used, it shall be positioned so that the puddle flange is in the centre of the wall. Where the double-flanged type is used, it shall be positioned so that the outside face of each flange is flush with the face of the wall. Pipe sup-port blocks shall be provided by the Contractor where necessary in chambers to support the pipe adequately, both during and after construction.

Surfaces of cast iron or steel pipes, which are to have concrete cast against them, shall be clean and free of deleterious matter and loose rust at the time of concreting. The paint protection system, to be applied to the permanently exposed faces of these pipes before the pipes are built in, shall be continued for 50 mm as marginal stripes along the contact surface. No paint containing aluminium in metallic form shall be allowed to come into direct contact with the concrete.

8.3.10 Lifting devices

8.3.10.1 Design standards

Generally, for design, stress calculation, manufacture and installation, the requirements of DIN 4100, DIN 4114, DIN 4132 as well as DIN 15018, DIN 15020 and DIN 15030, apart from all other relevant standards and regulations, shall be applied.

The Contractor shall state the design and calculation standards applied and the factors of safety for the different load combinations and the various equipment components.

All lifting equipment will be subject to a test operation over the entire service area with an overload = 1.25 x nominal load. The crane girders and runway tracks shall be calculated for a deflection not exceeding 1/1,000 of the span at maximum nominal load. Steel structures of lifting equipment shall be of welded construction, to be assembled at site. All field connections and joints shall be bolted.

For lubrication, inspection and maintenance, ladders, platforms or stairs shall be provided. All walkways shall have non-slip chequered plate treads and/or non-slip floor grating and shall be

equipped with tubular handrails and skirting. Walkways, stairs and platforms for lifting equipment shall be designed generally for a live load of 3,000 N/m².

6.3.10.2 Material standards

The material for the fabricated steel structures of lifting equipment shall be of weldable structural mild steel. The use of high strength and fine grain steels requires the explicit approval of the Engineer.

Allowable stresses for structural parts and connections are stated in DIN 15018. The stresses between the track rails, their fixing elements and the concrete shall not exceed:

•mean compressive stress 7.0 N/mm²
•compressive stress on edges 10.0 N/mm²
•bond stress 0.8 N/mm²

8.3.10.2 Particular elements' requirements

All wheels shall have a hardened tread with a minimum Brinell hardness number of 400, and shall be made of carbon steel or low-alloy steel forging. Bridge and trolley wheels shall have double flanges. Flexible couplings shall be installed to relieve the bearings and shafts from any stress due to misalignment and to facilitate the removal of motors, wheels and gears. The motor couplings also shall be of the flexible type.

All couplings, drive wheels and gears shall be press fit and keyed to the shaft. All bearings preferably shall be roller or ball bearings designed to permit easy shaft disassembly and easy replacement. The minimum average lifetime under design load conditions shall be 5,000 hours.

For cranes and hoists with a capacity larger than 500 kN, all bearings except those for the hooks and rope block sheaves shall be lubricated by a central lubrication system. An independent system for the trolley and one or two independent systems for the bridge will be acceptable.

The central lubrication system shall satisfy the following requirements:

- The lubricant quantity for each bearing shall be variable;
- Lubricant filters shall be installed in every lubricating pipe.

All gear transmission shall be of the oil bath lubricated helical gear type or similar. Low-speed spur gears may be lubricated with soft grease. Suitable oil and grease catching drip pans shall be installed and be readily accessible for draining and cleaning.

Brakes shall be of the spring-set type, electrically (solenoid or electro-hydraulic) released shoe or disc brake. The capacity shall be at least:

- for bridge and trolley drives 1.5 times and
- for hoist drives 2.0 times the full operating torque of the drive.

The run-out time of hoist brakes (time between cut-out of current and complete stop) shall not exceed 0.8 seconds. The brake shall automatically be applied when the motor control switch or the main power switch is in the "off" position and/or when the current fails on any one phase.

8.3.10.3 Overhead travelling gantry crane

Not Applicable

8.3.10.4 Hoists

The Contractor shall furnish manual hoists of the type most suitable for particular application under consideration. The hoists shall be suitable for mounting on the carriers or trolleys, which are furnished by the manufacturer of the overhead track system. The carriers or trolleys from which the hoists are suspended shall be provided by the Contractor.

8.3.10.5 Monorail Crane

Monorail cranes shall comply with the following and be complete with hoisting arrangement. Track shall be a specially rolled or fabricated section and shall be considered as a simple beam in determining capacity. In determining the capacity of the track the load on the load carrying (tension) flange shall be assumed to be at the point central with the wheel tread. The allowable stress on the tension flange shall be 20%of the ultimate strength of the mate-rial used.

All necessary clamps, hanger rods, and other fittings from which a track is suspended shall be considered as part of the track system. Track hangers shall support the load resulting from the maximum loading condition. The allowable stress for hanger rods shall be deter-mined from the root area of the rod. Means shall be provided to allow for the vertical adjustment of the track both before and after the system has been put in operation so that track can be erected and maintained.

Where the track is suspended from hanger rods, track shall be braced laterally and longitudinally to prevent excessive sway. Where the track is suspended from hanger rods, lock nuts or other means shall be provided to prevent the nuts from backing off the rods. Where multiple rods are used at a suspension point, consideration shall be given to the unequal load induced in the rods.

In the design of hanger rods, the allowable stress shall be 20% of the ultimate strength of the material used. Carrier yokes shall be of the swivelling type. Wheels shall be drop forged or rolled steel with heat treated treads and flanges or cast iron with chilled tread and shall have a minimum treat hardness of 400 Brinell.

Wheel bearings shall be single or double row, combination radial and thrust, anti-friction precision type. Bearings shall be pre-lubricated and sealed or provided with fittings and seals for pressure lubrication. Bearings shall be selected to provide a minimum B-10 life of 5000 hours.

Bearing life shall be based on 75% of the wheel load (impact need not be included), assuming a speed of 46 m/min for manually propelled carriers.

8.3.10.6 Name plates

Name plates shall be permanently attached to the bridge and load block. Capacity shall be stated in kilograms or tonnes. Name places shall be clearly legible from the floor and shall contain the manufacturer’s name and address.

8.3.10.7 Tests

Factory tests shall be carried out in the presence of the Engineer or his representative.

After installation, the unit shall be put through all of its operations, 125% of normal operating load, in presence of the Engineer or his representative. Inspections shall be made for proper installation, operation, alignment and lubrication. On conclusion of the tests to the satisfaction of the Engineer, he shall be given manufacturer's Test Certificates.

8.3.11 Fire protection equipment

Carbon dioxide fire extinguishers of the pressurised type having a trigger release and to comply with the requirements of EN 3-6 shall be installed on wall mounted brackets. The capacity shall be 7 litres of carbon dioxide.

Dry powder, pressurised with carbon dioxide, fire extinguishers being plunger operated and also to comply with the requirements of EN 3-6 shall be installed on wall mounted brackets with protection covers. The capacity shall be 5 kg of dry powder.

The extinguishers shall be provided with a pre-fitted flexible non conductive discharge hose having a flared end. Fire blankets shall be 1.5 meter square asbestos type supplied in a wall mounted container.

The equipment shall be mounted, with operation instructions printed on a metal plate in Eng-lish and Swahili language, at positions where directed by the Engineer.

Fire extinguishers shall be painted "fire red".

8.4 Treatment Process Equipment

8.4.1 Design and Material Requirements

8.4.1.1 General design requirements

The following directions, information and technical requirements for layout, design supply and erection shall be observed as far as they are applicable for all equipment to be offered. The technical requirements stated in the Technical Specifications are valid for all equipment, except only where additional and/or special requirements are specified.

Whenever a Tenderer deviates from these Specifications and Drawings, he shall furnish the data called for in the technical data sheets and give a summary of and the reasons for all deviations in a "List of Technical Deviations from Specifications". Failure to provide such a list may cause invalidation of his Tender, especially when a major deviation is involved.

Any changes of the design of any part of the equipment, which may become necessary after signing the Contract, shall be submitted in writing to the Engineer for approval, being sufficiently substantiated and justified.

Additional cost will only be accepted in case the Employer has changed the basis of the design after award of Contract. However omissions on the part of the Contractor on specified items of work of this contract shall not be considered for additional cost.

The regulations, standards and guidelines listed in these Specifications shall be observed in the design, calculation and manufacture.

All parts of the plant shall be suitable in every respect for continuous operation at maximum output under the climatic conditions and operating conditions peculiar to the site.

It is further expected that all parts of the plant shall be adequately and generously dimensioned.

Special attention shall be given to equipment, parts of which are delivered by different manufacturers. Problems arising in this conjunction shall be solved by joint effort of all participants and shall be defined in writing.

8.4.1.2 Functionality

The plant shall be designed, manufactured and arranged so that it possesses a functional design and pleasant appearance. All parts of the works shall be arranged in a simple manner to facilitate surveillance by the operator, easy maintenance and operation, and all control movement shall be reasonable and obvious.

The parts of the plant shall be designed and arranged so that they can be easily inspected, cleaned, erected and dismantled without necessitating large scale dismantling of other parts of the works. They shall be designed and manufactured in accordance with the latest recognised rules of workmanship and modern Engineering practice.

For individual items of plant, materials and design are to be selected which are best suited for operating conditions to which the parts in question will be subjected. Only such design and types of equipment shall be offered which have been tested in long-term continuous operation. Innovations cannot be accepted for the Main Tender but may be offered additionally as an alternative proposal.

8.4.1.3 Protection / safety

All live, moving and rotating parts shall be provided with appropriate effective protection in order to avoid danger to the operating staff. All metal parts shall be electrically grounded. Manufacturers shall take appropriate measure to prevent the ingress of dust into any equipment (such as bearings, relays, control and measuring equipment, etc.), which may be endangered thereby.

Suitable lifting eyes and backing-out bolts shall be provided where they are required or where they will be useful for erection and dismantling.

Sockets and depressions likely to hold water shall be avoided in the design, and if not avoidable, they shall be properly drained.

Large or heavily loaded ball and roller bearings shall be protected against deformation and vibration during transport. If the bearings have been deformed, they shall be exchanged at site against new ones free of charge.

Parts of the plant intended principally for standby purposes shall be protected from corrosion by careful choice of material and by additional means; which should not reduce their continuous standby readiness.

8.4.2 Relevant standards

The Contractor shall carry out works described in this Specification in accordance with the appropriate EN and DIN Standards. These are, but are not limited by, the following:

- DIN 2403 Identification of pipelines according to the fluid conveyed
- DIN 2501 Flanges; Connecting Dimensions
- DIN 2642 Loose flanges
- DIN 3230-4 Technical Conditions of Delivery for Valves; Valves for Potable Water Service, Requirements and Testing
- DIN 4100 Welded steel structures
- DIN 4114 Steel structures stability
- DIN 4132 Crane ways, steel structures, calculations and design
- DIN 4056 Water pipelines; valve boxes for stop valves; DVGW code of practice
- DIN 8974 Polyethylene (PE) pipes - Dimensions
- DIN 15018 Cranes, steel structures, stress analysis
- DIN 15020 Lifting applications basic principles for Rope Receiving components
- DIN 15030 Cranes, acceptance ad testing of cranes

- EN 3 Portable Fire Extinguishers
- EN 294 Safety of machinery. Safety distances to prevent danger zones being reached by the upper limbs
- EN 593 Industrial valves - Metallic butterfly valves
- EN 773 General requirements for components used in hydraulically pressurised discharge pipes, drains and sewers
- EN 837-1 Pressure gauges. Part 1 : Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing.
- EN 1171 Industrial valves - Cast iron gate valves
- EN 1452 Plastics piping systems for water supply - Unplasticized polyvinyl chloride (PVC-U)
- EN 1561 Founding. Grey cast irons
- EN 1563 Founding. Spheroidal graphite cast irons
- EN 1676 Aluminium and aluminium alloys. Alloyed ingots for remelting. Specifications.
- EN 1706 Aluminium and aluminium alloys. Castings. Chemical composition and mechanical properties.
- EN 1982 Copper and copper alloys - Ingots and castings
- EN 10083 Steels for quenching and tempering
- EN 10088 Stainless steels
- EN 10216 Seamless steel tubes for pressure purposes
- EN 10217 Welded steel tubes for pressure purposes
- EN 10255 Non-alloy steel tubes suitable for welding and threading
- EN 10293 Steel castings for general Engineering uses
- EN 12334 Copper and copper alloys - Ingots and castings
- EN 12540 Corrosion protection of metals

- ISO 898 Mechanical properties of fasteners made of carbon steel and alloy steel
- ISO 1217 Displacement compressors. Acceptance tests
- ISO 1461 Hot dip galvanised coatings on fabricated iron and steel articles. Specifications and test methods
- ISO 3046 Reciprocating internal combustion engines

- ISO 7005 Metallic Flanges
- ISO 8528 Reciprocating internal combustion engine driven alternating current generating sets
- ISO 9905 Technical specifications for centrifugal pumps
- ISO 5199 Technical specifications for centrifugal pumps - Class II
- ISO 9908 Technical specifications for centrifugal pumps - Class III
- ISO 9906 Rotodynamic pumps - Hydraulic performance acceptance tests

The Contractor may carry out the works or provide materials in accordance to local or other international standards (BS, ISO and others), provided their requirements are superior or equivalent to the quality described by the standards cited in the Specifications.

8.4.3 Standardisation of equipment

As far as possible, measures shall be taken to standardise certain parts of the equipment throughout the works to be installed under the present project in order to facilitate keeping stocks, maintenance, replacement and interchange ability.

The types and makes of equipment to be used shall be as per vendor list and/or approved by the Engineer, if the same is not mentioned in the vendor list.

All instrument indicator scales shall be in the English language with units in the international SI-System.

8.4.4 Identification plates

As far as applicable, all parts to be delivered under the Contract shall be labelled with permanent identification plates in readily visible locations. The identification plates shall be protected during erection and especially during painting. Damaged or illegible identification plates shall be replaced. The identification plates shall be of non-corroding, non-disintegrating material and shall be labelled in English language.

Printed or stencilled inscriptions shall be waterproof, oil-proof and wear resistant. Equipment (machines, transformers, etc.) nameplates shall be of enamelled type or stainless steel coated with a transparent lacquer.

The following data shall be shown in accordance with the relevant standards:

- Manufacturer's name and address;
- Manufacturer's serial number and date of manufacture;
- Main design data.

Standardised components, such as small or medium sized electric motors, transformers, instruments, etc., with the manufacturer's standard nameplate are acceptable.

Each part appearing under a certain symbol or number in functional diagrams, piping diagrams, operation and maintenance instructions, etc., shall be equipped with a plate showing the same symbol or number.

Warning signs and plates for designations or instructions for operation, safety and maintenance shall have a uniform design and shall be inscribed in English and Swahili language.

8.4.5 Instruction manuals

The Contractor shall submit to the Engineer not later than two months before commissioning, duplicate draft copies of the Operating and Maintenance Instructions in Swahili and English for all sections of the works. The operating instructions shall be prepared in such a way as to provide a step by step description of the preparation and setting to work of the whole of the works and its shutting down.

The instruction manuals prepared by the Contractor and manuals relating to plant by any sub-contractors shall be printed (not duplicated) and shall be bound into suitable loose leaf binders A4 size.

Following successful commissioning and not later than two months after the Employer has taken over the works, the draft copies, suitably corrected where necessary, shall be assembled into their final form and shall be submitted to the Engineer for approval.

The Contractor's attention is drawn to the need to ensure that the following items are included in the manuals:

- Schedule of equipment supplied, giving manufacturers name and model No.
- Schedule of routine maintenance for all equipment supplied.
- Schedule of spares supplied
- Schedule of tools and lubricants supplied
- Sectional arrangement drawings of major items of plant, i.e. pumps, valves etc., with dismantling instructions.
- Plant layout drawings showing the “As Erected” installation.
- General arrangement and schematic diagrams of the “As Installed” control panels
- “As Wired” diagrams of all electrical connections
- Full and comprehensive instructions for all items of equipment supplied.
- Test certificates for all equipment for both works and site
- Schedule of recommended lubricants and their equivalents.

At each location for each type of equipment there shall be supplied and mounted on the wall in a conspicuous position:

- 1 board mounted Schedule of Routine Maintenance to be carried out on plant
- 1 board mounted Set of Instructions for Operation of the plant

The print on each board is to be of large clear type in Swahili and English. The issuing of the Maintenance Certificate shall be subject to receipt and approval of Operating and Maintenance Instruction by the Engineer.

9. ELECTRICAL EQUIPMENT

9.1 General requirements

The following clauses shall specify general electrical requirements and standards of workmanship for the plant, equipment, and installation materials. General specification clauses shall apply where appropriate except where particularly redefined in the individual specification clauses.

9.2 Relevant standards

All electrical work must be carried out by personnel in possession of a current licence acceptable to the Authority, which permit the Contractor to carry out work on low voltage equipment and cabling. The Contractor shall carry out works described in this Specification in accordance with the appropriate EN, IEC Standards. These are, but are not limited by, the following:

- EN 418 Safety of machinery. Emergency stop equipment, functional aspects
- EN 837 Pressure gauges
- EN 1050 Safety of machinery. Principles for risk assessment.
- EN 60204 Safety of machinery - Electrical equipment of machines
- EN 60269 Low-voltage fuses
- EN 60439 Low-voltage switchgear and control gear assemblies
- EN 60947 Low-voltage switchgear and control gear

- IEC 76 Power transformers
- IEC 185 Current transformers
- IEC 227 Polyvinyl chloride insulated cables of rated voltages up to and including 450/750 V
- IEC 364 Electrical installations of buildings
- IEC 446 Identification of insulated and bare conductors by colours
- IEC 529 Degrees of protection provided by enclosures (IP code)

- ISO 3046 Reciprocating internal combustion engines - Performances
- ISO 5167 Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full
- ISO 12100 Safety of machinery - Basic concepts, general principles for design

- IEC Standards

Any other codes and standards and approved by the Consulting Engineer where the equipment or part of it complies with other internationally recognized standards, which are less stringent than the above-mentioned standards, the differences are to be stated in writing and must accompany the tender submission.

Any particular requirements of the EN or IEC standards shall take precedence to any other standards. All electrical equipment shall be approved by the Electrical Supplies Company.

9.3 Regulations

Additionally, the manufacture of equipment and the complete installation shall be carried out and tested in accordance with the latest issues or amendments of the following regulations, as applicable:

- The National Electricity Ordinance
- The National Factories Ordinance
- The National Building Regulations
- The Standards and Regulations as issued by the National Electricity Company
- The local Fire Regulations as issued by City Council
- The Regulations as issued by the National Telecommunication Company

9.4 Engineering Data

Technical descriptions, data sheets, calculations, catalogues and other materials submitted with the Tender must enable the EMPLOYER to thoroughly evaluate the proposal so as to assess its compliance with the Specifications. The minimum requirements for submission of data are:

- Detailed summary of deviations from the specifications with reasons must submitted be-fore supplying. The tenderer shall only propose and supply materials primarily specified in the Bills of Quantities. The Engineers shall first approve any alternative material specifications before they are ordered.
- Completed data sheets, filling in of bid data on data sheets as attached to tender documents;
- Brochures and catalogues containing outline dimensions, main electrical data, and installation details;
- Listing of accessories included in the Tender;
- Applicable design specifications based on calculations and inquiries;
- Tests included

9.5 Engineering Services

The Contractor shall supply the documents and shall additionally supply one of drawings as reproducible tracing (CD)

9.5.1 Scope of technical documents to supplied by Contractor

9.5.1.1 Process documents

9.5.1.2 Piping and instrument diagram containing:

- All machinery and plant identified by item numbers
- All piping identified as to nominal size and piping class and including valves and fittings
- All instrument points and control circuits
- All drains, vents, purge connections and sampling points

9.5.1.3 Operation and maintenance instructions containing:

- Description of operation of overall plant and separate plant sections together with separate instructions for:
- Placing beds and packings in respective units
- Commissioning
- Normal operation
- Shutdown
- Fault condition and correction
- Emergency shutdown

9.5.1.4 List of analytical procedures containing :

- Breakdown of analyses applicated to fulfilment of guarantees.
- Breakdown of analyses applicable to running supervision of plant operation.

9.5.2 Main equipment (plant and machinery)

9.5.3 Piping Plan containing:

- All plant units and machinery
- All piping of 25 mm and larger
- All valves

9.5.3.1 Instrumentation and Control

9.5.3.1.1 Instrument specifications

9.5.3.1.2 One – line circuit diagram

9.5.3.1.3 Instrument panel lay out containing:

- Scale drawing of panel front , with flow diagram
- Instrument identification with instrument point number

9.5.3.1.4 Terminal and wiring diagram

9.5.3.1.5 Functional description

For complete control system

9.5.4 Electrical equipment

9.5.4.1 General arrangement circuit diagram

9.5.4.2 Motor specification

9.5.4.3 Motor list containing:

- Motor number
- Quantity
- Designation
- Design class, enclosure class
- Nominal data
- Operating and starting data

9.5.4.4 Cable list containing:

- wire numbers
- Target designation
- Wire type, number of cores
- Wire length

9.5.4.5 Terminal diagram containing:

- Lead number
- Terminal number
- Beginn and end of connecting wires

9.5.4.6 Low – tension distribution lay out plan containing:

- Scale drawing of panel front, with flow diagram
- Device identification with device point number

9.5.5 Construction and structural steelwork

9.5.6 Basic civil Engineering and foundation drawings (scale 1 : 25 or 1 : 50)containing :

- Plan representation of building for each level
- Foundation dimension
- Penetrations and openings
- Static and dynamic loads and their points of applications

9.5.7 Miscellaneous

9.5.7.1 Inspection, inspection certificates

Covering inspection of equipment subject to official inspection

9.5.7.2 Time – tables

Time tables (bar charts) for all supplies and services undertaken under contract

9.6 Commissioning

9.6.1 Requirements

The requirements for a proper execution of commissioning are as follows:

- All civil and erection works shall be so far complete as is deemed necessary by Contractor.
- The plant components shall be cleaned be clean and easily accessible. All concrete tanks
- Shall have been tested for leaks. The hydraulic test certificates shall be available.
- The clear water reservoirs shall be absolutely free from fouling.
- All necessary interconnecting pipework shall have been made and tested and the discharge of waste and overflow water and of clear water shall be ensured.
- The high - voltage plant shall be connected to the high – voltage system and all low – voltage distribution shall ready for operation.
- The work shall be carried out by Client`s personnel under the supervision of the Contractor`s Start – up personnel.
- All work shall be agreed in advance with Client`s start – up personnel.

9.6.2 Duration

Start-up of plant shall be as quickly as possible after complation of erection in accordance with
- The completion certificate and will take approx. 8 (eight) weeks.
- Following that the function test over approx 3 (three) weeks shall be performed.

9.6.3 Performance of Commissioning

Commissioning shall be performed in a sequence to be specified and agreed by both sides in case of contract.

9.7 Function Test / Take – Over

- The function test serves the purpose to demonstrate the guarantees specified in tender. During the first 3 (three) days the plant is operated at nominal capacity.
- During the following 4 (four) days the plant will operated at the upper and lower limits of the Indicated capacities.
- The necessary analyses shall be carried out at the earliest 4 (four) hours after changing the capacities.
- The duration of the maximum capacity of the individuals plants shall calculate with 12 (twelve) hours.
- The function test shall be performed under the same personnel responsibilities as the commissioning.
- The results of theses tests shall be laid in a report.
- All examination results shall become an integral part of this report.
- Following the successful function test the preliminary take – over places by client.

9.8 Training of Staff

During commissioning, the client`s staff will be trained by Contractor`s personnel.

9.9 Manufacturer's documentation

Materials, equipment or any apparatus supplied by others for incorporation into the installations by the Contractor shall be carefully examined on receipt. Should any defects be noted the Contractor shall immediately notify the Consulting Engineers prior to incorporating them into the Works.

The electrical equipment supplied under the contract shall be so documented as to allow the EMPLOYER, (as well as the operator), to fully understand the product, its theory of operation, its application and performance. The following documents shall be submitted to the Engineer:

- Operators Manual;
- Trouble shooting, diagnosis, service and maintenance manual;
- System Technical manual;
- Field wiring schedules, including identification of all wires, terminals, and terminal strips;
- Complete schematic diagrams of all control gear inclusive of pump motor control panels
- Spare parts location, identification and parts list;
- Installation and commissioning instructions.

9.10 Workmanship

Particular attention shall be paid to the neatness of appearance of the electrical installation; arrangements of which shall be agreed upon by the Engineer before the commencement of installation if the contractor proposes positions of equipment deviating from specified arrangements in drawings. The Contractor shall ensure that the installation is completed to the highest standards of quality and neatness with respect to the visible appearance of cable runs and the arrangement and alignment of equipment, apparatus and fittings.

The general requirements for electrical building services are given in the specifications, in the Bid Documents, but the Contractor shall determine the quantities and locations of fit-tings and equipment and shall prepare surveys and detailed design with installation arrangement drawings. The final locations of all building services, fittings and equipment shall be agreed at site with the Engineer before installation.

The Contractor shall arrange for the switch-gear and panel manufacturers to provide skilled labour for the supervision of off-loading, placing in position on prepared foundations, erection and commissioning of all switch-gear and control panels.

9.11 Materials

All materials incorporated in the works shall be most suitable for the duty concerned and shall be new and of first class commercial quality free from imperfection and selected for long life and minimum maintenance.

The use of dissimilar materials in contact shall be avoided, but where unavoidable these materials shall be selected so that the natural potential difference between them does not exceed 250 mV. Electro-plating or other treatment of contacting surfaces shall be employed as necessary to reduce the potential difference to the desired limit.

All materials and material finishes shall be selected for long life under the climatic conditions at Site. Materials used in ventilated or air-conditioned areas shall be selected to allow for the conditions expected in case of failure of the ventilation or air-conditioning equipment. Tropical grade materials and panel components shall be used except if not available.

9.11.1 De-rating due to climatic conditions

All ratings of equipment and components shall be interpreted as site rating and NOT sea level or other ratings.

All electrical equipment cables and wiring shall be de-rated for the specified site climatic conditions in accordance with the factors of the relevant design standards.

9.11.2 Polarity

The polarity of all apparatus used for the Works specified shall be arranged as follows when viewed from the front:

- For two pole apparatus, the phase or live pole at the top (or left-hand side) and the neutral or earthed pole at the bottom (or right-hand side). On plug and socket outlets, the polarity shall conform to EN, IEC, or approved standards as appropriate for the country.
- For three or four pole apparatus the phases in the order L1, L2, L3 and neutral reading from top to bottom or left to right in the case of vertical and horizontal layouts respectively.
- Phase colours and sequence shall be according to national regulations of the country (i.e. RED, YELLOW and BLUE FOR 3 phase conductors, BLACK for neutral conductor, and GREEN or GREEN/YELLOW stripes for earth conductor)
- All cable cores shall be identified with phase references.

All non-flexible cables shall be connected between main switchboards, Motor Control Centre (MCC), distribution boards, plant and accessories so that the correct sequence of phase col-our is preserved throughout the system.

On building services wiring installations, where more than one phase is incorporated on a common system in one room, then the live cores shall be phase identified as appropriate and fittings and switch accessories shall be permanently labelled and segregated in accordance with the relevant clauses of the EN or IEC standards.

9.11.3 Safety interlocks

A complete system of electrical and mechanical interlocks and safety devices shall be provided throughout the electrical installation for the safe and continuous operation of the plant in order to ensure:

- Safety of personnel engaged in operational and maintenance work on the plant.
- Correct sequence of operation of the plant during start up and shut down.
- Safety of the plant when operating under normal or emergency conditions.

- Interlocks shall be preventive and not corrective in operation.

The Contractor shall be responsible for the preparation of interlocking schemes for the approval of the Engineer.

9.11.4 Switchboards and motor control centres

LV switchboards and Motor Control Centres shall as far as possible be control centres manufactured by a single approved supplier and the construction of each individual panel shall be such that all components shall be selected for standardisation.

Fully type tested designs to the fault levels specified with ASTA or KEMA certification is required. LV switch-gear (distribution boards) shall be designed and constructed in compliance with IEC 439-3, and control boards (MCC) etc., shall be designed and constructed in compliance with IEC 439-1. Form 3b barrier shall be adhered to all types of boards.

Switchboards shall be so positioned that access thereto shall not be obstructed by the structure or contents of the building. A distance of not less than 900 mm shall be provided and maintained in front of every switchboard/panel board for the purpose of safety and effective maintenance, operation and adjustment of all the equipment mounted thereon.

Where a switchboard incorporates rack–out switch-gear, doors or hinged panels there shall be a clearance of not less than 1200 mm between any wall or immovable structure and the switch-gear, doors, or hinged panels when it is in the racked–out or in open position. The racked out position of the switchgear must be effectively earthed in the racked out position for electrical safety.

Rear access switchboards and panels shall be provided with unhinged lift–off panels only. Hinged panels will not be permitted. All apparatus shall be positioned on a switchboard so that there is ample room for its safe and effective operation and handling. The maximum height of any operating controls shall not exceed 1,700 mm above finished floor level.

LV (Low Voltage) switch-gear shall be suitable for extending at either end and arranged so that additional cubicles may be installed in position and cables only made off while the existing busbars are not in operation. To gain access to the busbar, for the purpose of extending, it may only be necessary to remove external end covers.

Each switchboard panel or section shall be fitted with a de-mountable metal cable termination gland plate positioned at vertical or horizontal level but with adequate space for termination of cables, conduits, etc. The gland steel plates shall be efficiently earthed to the panel earthing system by a separate earthing conductor. The base of the panels shall be provided with removable plates of PVC or steel type to seal the cable/conduit entry.

All switch-gear shall be provided with lifting eyes, which shall be removable and replaced, at site, with chrome plated screws.

9.11.5 Multi-cubicle-type assembly

Cubicles shall be constructed of not less than 1.5 mm thick sheet steel and be of a totally enclosed welded construction with covers and hinged front doors interlocked as specified. Panels shall be arranged for front access only.

Low voltage switch-gear and control boards and individual enclosures for installation in in-door locations shall have a minimum protection enclosure of IP54. Compartments shall be easily accessible for maintenance purposes. Barriers shall be included between each compartment to ensure safe maintenance on any out–going circuit when the remainder of the board is live.

Cubicles shall not rely on any removable portion for their rigidity. All live terminals of equipment mounted on cubicle doors and/or enclosure covers shall be adequately screened unless protected by an interlocked isolator. All doors and hinged covers shall be efficiently earthen by a separate conductor.

All terminations for out–going cables, including lighting fittings, socket outlets, etc. shall be provided with terminals. Termination at fuse switches and miniature circuit breakers will not be acceptable.

Switchboards and panel boards shall be complete with the necessary interconnections, small wiring, labels and copper busbars, the interconnections being referenced to indicate phases, and they shall be properly earthed.

Where interconnections occur between various panels, the Contractor shall ensure that wire/terminal numbers have identical references.

9.11.6 Safety

Interlocks shall be provided so that it is not possible to gain access without tools to any compartment containing uncovered live connections unless all such equipment inside the compartment is isolated from the supply.

Where access to low voltage enclosures is necessary with equipment energised from an external source all equipment, terminals shall be fully shrouded to prevent accidental contact and warning labels shall be fitted. Safety barrier shall have a minimum degree of enclosure IP2x.

9.11.7 Switch-gear earthing works

Single enclosures shall be provided with an earth stud or earth busbar. Multi-cubicle type enclosures shall be provided with a continuous earth busbar, which shall extend over the full length. Each cubicle shall be bonded to the earth busbar. The earth busbar shall be provided with two terminal assemblies for connection to the installation main earth terminal.

The short-time rating of the earth busbar and connections shall be not less than that of the associated equipment, or the maximum through-fault current of the power source. The temperature rise of the busbars and connections under fault conditions shall not cause damage to the connections of any equipment to which they may be connected.

Earth terminal bolts or studs shall be brass and shall not be less than 8 mm diameter.

9.11.8 Main switches

The main switch or switches of every installation shall be marked as such and shall be identifiable from other switch-gear by grouping, colouring or other suitable means, such as to ren-der it (or them) easily located in an emergency. When there is more than one main switch in any building, each shall be marked to indicate which installation or section of the installation it controls.

In a cubicle main switchboard, the main controlling switch (or switches) shall be located in their own section, completely segregated from all other parts of the switchboard with front access. All main switches on main switchboards (of either cubicle type or otherwise) shall be so located, that a minimum distance of 900 mm exists from the finished floor level to the bot-tom of the switch or connection straps, whichever is the less.

9.11.9 Distribution sections

Distribution sections shall contain miniature circuit breaker outgoing ways for the required circuits plus approximately 20% of spare ways. Access to the distribution board shall be possible without opening the associated fused isolator, but access to the fused isolator shall only be obtained with the isolator open. Miniature Circuit Breakers (MCB's) shall be insulated moulded case, non-adjustable, magnetic and thermal tripping type. MCB's shall comply with EN/IEC standards for isolating and switching. MCB's shall have a rated current and category of duty of not less than M4 or as otherwise specified to match the fault rating of the switch-gear. Back-up fuses shall be provided as required, but the ratings of the MCB's must be correctly co-ordinated with the fuse to achieve the necessary degree of fault co-ordination. Loads on distribution sections shall be balanced between the three phases as far as possible.

9.11.10 Busbars and busbar connections

All busbars and busbar connections shall be of hard drawn high conductivity copper. Busbars and connections shall be identified by phase coding and adequately supported by suitable insulators. The whole installation shall be mechanically and electrically designed to with-stand the full fault capacity. All busbars and connections shall be rated for continuous operation. The Contractor shall provide type test certification for the busbar and primary connection short circuit withstand and thermal performance.

Low voltage switch-gear busbars and connections shall be identified throughout their entire length.

9.11.11 Cable boxes, gland plates and terminations

The arrangement of cable boxes, gland plates and terminations shall permit easy installation. Cable gland plates shall be manufactured from sheet steel for multi-core cables and non-ferrous material for single core cables. Gland plates shall be mounted not less than 300 mm above the base of the enclosure.

Space for cabling within terminal enclosures shall be not less than that stated in EN standards. Adequate space shall be provided for the termination of oversize cables.

When the cable gland is remote from the cable terminals, purpose made cable tray or trunking shall be provided within the enclosure for securing or accommodating the cable cores. Terminals for small low voltage power and auxiliary circuit application shall be fully insulated, and shall be of pillar type with indirect pressure plates unless otherwise approved by the Supervisor.

Terminals in a common compartment associated with different voltages or circuit types shall be segregated into clearly identified groups. Barriers shall be provided between each group. Terminals shall be provided for the connection of all cable cores and, where applicable, core screen drain wires.

Not more than one core of internal or external wiring shall be connected to a terminal. Where duplication of terminals is necessary, purpose made solid bridging links shall be fitted.
Terminals, which remain energised when the main equipment is isolated, shall be shrouded and fitted with a warning label.

9.11.12 Auxiliary switches

Auxiliary switches for indication, protection, interlocking and supervision purposes shall be readily accessible and enclosed in a transparent dust proof cover or equal cover. Adequate secondary disconnection shall be included between the fixed portion of a circuit breaker and the moving portion.

Spare auxiliary contacts, one normally open and one normally closed, shall be provided on each unit.

9.11.13 Isolating switches

The compartment isolating switch shall interrupt all supplies into the compartment to enable safe maintenance to be undertaken. Isolators shall have “ball and stick” type handles and a fixed post shall be provided to enable the isolator to be padlocked in the off position only. One padlock with 4 keys shall be supplied for each isolator on the board.

9.11.14 Auxiliary wiring and terminal blocks

Wiring used for internal connections shall be capable of withstanding, without deterioration, the conditions on site, due allowance being made for such temperature conditions as may arise within any enclosure.

Butyl rubber/CSP insulated cables shall be employed or alternatively PVC-insulated cables to VDE 0250 suitably de-rated if necessary.

Single-strand wire shall not be used. Wires shall not be less than 1.5 mm2 total cross-sectional area. Both ends of every wire shall be fitted with full ring interlocking ferrules of white insulating material. Letters and numbers shall read from terminal outwards and shall correspond to the appropriate wiring diagram. Crimped on terminal connectors shall be fitted to all wire ends.

Unless otherwise specified or approved, wiring shall be coloured as EN 60204-1 and IEC 446.

Wiring shall be supported in insulated cleats or cable trunking. Wiring passing between compartments which may be separated for transport shall be taken to terminal blocks mounted near the top of each compartment, separately from those for external cable connections. The busbar chambers of the equipment shall not be used as trunking for small wiring.

All terminals which may be live when a compartment door is open shall be shrouded and provided with warning labels.

Connections to apparatus mounted on doors or between points subject to relative movement, shall be made in flexible wires, arranged so that they are subjected to torsion rather than bending. The Contractor shall submit for the Engineer's approval, samples of the types of wires, numbered ferrules, and terminal washers or lugs, if appropriate, which he proposes to use.

9.11.15 Indicating lamps

On AC operated circuits, indicating lights shall be of low voltage type with self-contained transformers. The lamps shall operate at not greater than 90% rated voltage to ensure long life.

On DC operated circuits suitably rated resistances shall be connected across each lamp operating contact.

Lights shall be well ventilated and be designed to permit the removal of the lamp glass and lamps from the front of the unit. Lamps units shall be of the “push to test” type to facilitate testing, or a separate “LAMP TEST” button for the whole control board/switchboard shall be installed.

9.11.16 Indicating instruments and meters

All indicating instruments and meters shall be flush mounted and generally of the same appearance throughout. They shall comply with relevant standards and shall be of industrial grade accuracy. They shall be sealed against the ingress of moisture and dirt.

Indicating instruments shall be of 270° scale type and shall have an external zero adjustment. They shall be positioned so that they can be easily read and the dial centres shall be not less than 400 mm and not more than 1700 mm above finished floor level. Instruments shall be fitted with an adjustable pointer or shall be inscribed on the scales to indicate the normal circuit rating for the associated circuit.

All indicating instruments shall have a square front appearance with width dimensions not less than 96 mm. Am- or kW meters fitted in a motor winding circuit shall be provided with adjustable red pointers. All instruments shall be mounted adjacent to the relevant circuit breaker, switch or starter, unless separate panel suites are specified herein.

At points of connection of instrument and meter potential circuits to LV busbars, fuses shall be provided to protect the auxiliary wiring. For cubicle gear, these fuses shall be housed within the cubicle and be readily accessible. Additional fuses to clear individual instrument faults shall be provided and accessible from the front of the cubicle where specified.

9.11.17 Low voltage fuses

Low voltage fuse links shall be to EN 60269-2 and one spare fuse for each fuse fitted in the panel shall be supplied, clipped adjacent to the position in which it would be in service with reusable clips. A complete schedule of all fuses in the panel shall be affixed in a convenient position in the panel.

Fuse link carriers and bases shall be fully insulated and shrouded type, the design of which shall prevent contact with "live" parts while the fuse carrier is being, or has been withdrawn. Fuse holders and bases shall be manufactured of moulded plastic. Ceramic material will not be accepted.

9.11.18 Current transformers

Current transformers shall comply with IEC 185 and shall be of the wound primary or bar primary type according to the ratio required. Current transformers shall be suitably rated and designed to carry out appropriate metering and protection functions as indicated.

The rated capacity of current transformers shall not be less than the total capacities of all relays, instruments and related loads. Unless otherwise specified current transformers shall be of Class 1 accuracy for use with measuring instruments and Class 5P for protection circuit duties.

Identification labels giving type, ratios, rating, output and serial numbers shall be fitted. Duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without removal of any cover. Labels shall be supplied for multi-ratio current transformers indicating the connection required for alternative ratios.

Bar type current transformers shall be supplied in preference to those with wound primaries. Current transformers short-time current ratings shall relate to the full fault level for one or three seconds as applicable and shall be not less than that of the switch-gear in which they are incorporated.

Removable links shall be located on each phase of the switchboard primary conductors to enable easy current transformer maintenance and replacement. One secondary terminal of each current transformer shall be earthed through a bolted link located in the switch-gear instrument/relay panel.

9.11.19 Extra low voltage supplies

Where extra low voltage supplies are required for illumination and power supplies (hand lamps, installation liable to flooding, portable hand tools, etc.) they shall be obtained via a portable step–down transformer with a 220 V primary winding and secondary winding at 24 V.

9.11.20 Fault level

Where a switchboard is directly connected to the low voltage side of the transformer or a transformer without any distribution cut–out, then the complete switchboard shall be manufactured to comply in total with a short circuit rating of 50 kA for duration of one second minimum.

With transformer distribution cut–out, the minimum short circuit rating for Main Distribution Boards and MMC shall be 25 kA and Distribution Boards 15 kA.

All small wiring for controls, voltmeter supplies, etc., that originate from the main and sub–main busbars shall be protected by means of busbar mounted cartridge fuses suitably rated for the purpose intended. The maximum size of fuse used shall not exceed 20 amps.

9.11.21 Protection relays

Protective relays shall be provided, for fault and overload protection, to operate circuit breakers. The Contractor shall ensure that the form of protection proposed also meets the requirements of the local Authority.

The Contractor shall be responsible for ensuring that all details relating to the protection systems shall be submitted to the Engineer for approval and no work shall commence until such approval has been received in writing. All protective relays shall be manufactured by an approved manufacturer. They shall be suitable for climate and site conditions and fully sealed against the ingress of moisture and dirt.

Relays shall be suitably rated to operate at the specified DC auxiliary circuit voltage and shall have output contacts suitable for operation of the switch-gear tripping mechanisms and associated alarm and indication systems.

Secondary injection shall be easily possible by means of purpose-made voltage and/or cur-rent plug-in type test terminal blocks which automatically open or short circuit the integral voltage transformers or current transformer respectively and provide terminations for the test supply. Disconnection of any permanent wiring will not be acceptable.

Each individual element of the relays shall incorporate a visual operation indicator, which shall be reset by operating an external reset button mounted on the front of the relay case. Each relay shall be complete with panel mounting Works and terminals for external circuit connection.

Protection relays and associated equipment shall be as detailed in the specific clauses and as determined by the Contractor.

9.11.22 Low Voltage Circuit Breakers

Air break circuit breakers shall be rated for controlling loads for maximum circuit operation and 380 V 3 phases 50 Hz. 4 wire operation under the specified site climatic conditions. Test Certificates of the ASTA or KEMA type shall be provided for inspection with the Tender.

All low voltage circuit breakers shall be housed in control boards, which comply with the requirements of the Particular Technical Specification and shall not reduce the degree of protection to less than IP54.

Low voltage circuit breakers shall comply with EN 60947, shall be of the air-break type, and shall be moulded case or open construction (metal clad casing) design. For the purpose of this specification the two designs are referred to as moulded-case and air circuit-breakers. Circuit-breakers shall be Utilisation Category B and shall have a service short-circuit breaking capacity

not less than 50 % of the rated ultimate short-circuit capacity. Circuit-breakers shall be suitable for isolation and shall be to Overvoltage Category IV to EN 60947-1.

The rated current specified in the specific clauses shall be that with the circuit-breaker mounted within a switchboard. The service short circuit breaking capacity shall be not less than the maximum power system fault level. Unless otherwise specified, air circuit-breakers shall be used for rated currents of 630 A and above. Moulded case circuit breakers shall be provided where specified in the specific clauses.

Circuit breaker closing mechanisms shall be of the independent type. It shall be possible to manually charge power operated closing mechanisms. Works shall be provided for padlocking in the OFF position.

Each pole of moulded case circuit-breakers shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short-circuit protection. The thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated. Where available, the thermal magnetic elements shall be interchangeable.

Unless otherwise specified, air circuit-breakers shall be fitted with a solid state protection system. The protection system shall be fully self-contained, needing no separate power sup-ply to operate the circuit-breaker tripping mechanism.

Accessories such as shunt trips, undervoltage releases, auxiliary contacts and motor mechanisms shall be manufactured to allow easy installation. Closing mechanisms shall be suitable for operation at 80 percent of the nominal solenoid supply voltage. Closing and tripping batteries shall comply with the relevant clauses of the Technical Specification.
Auxiliary contacts for the indication of breaker state shall be provided.

Incoming feeder circuit breaker panels shall be provided with a purpose designed, separate earthing device. The device shall be arranged to earth either the cable box or the busbar side of the circuit breaker, and shall be stored in a suitable robust container which shall include a permanently fixed instruction label giving details of assembly and use. Auxiliary jumper connections, as necessary, shall be included.

9.11.23 Low voltage switches disconnectors and fuse switches combination units

Switches, disconnectors, switch-disconnectors and fuse-combination units shall comply with EN 60947-3 and shall be suitable for uninterrupted duty. Switching devices shall be suitable for isolation and shall be to Overvoltage Category IV to EN 60947-1

Unless otherwise specified, the Utilisation Category for switching devices shall be AC-23A for alternating current and DC-23A for direct current. Operating mechanisms shall be of the independent manual type with provision for locking in the OFF position. Fuse links for use in fuse-switch devices shall comply with relevant standards.

Combination units shall be contained within an enclosure of metal and shall be fitted with an earthing terminal or equivalent to enable the enclosures to be earthed irrespective of any means of connection such as is provided for attaching armouring or other metallic covering of the cable supplying the combination unit.

The enclosure shall be so constructed that the cover cannot be opened until the switch is fully opened and that when the cover is opened, a component examiner can override the interlock and operate the switch. After such operation, the cover shall be prevented from closing with the switch position indicator in a false position.

Switches and fuse switch units for switchboard installation shall be flush mounting. Switches shall be provided with mechanical ON/OFF indicators and operating handles. Means shall be provided for locking the switch in the OFF position only.

The fuse shall either include a suitable fuse carrier or it shall be capable of isolation. If the fuse carrier is included, it shall be such that when it is being withdrawn normally or when it is completely withdrawn, the operator is completely protected from accidental contact with any live metal of its fuse link, fuse contacts and fixed contacts.

If the fuse is capable of isolation, it shall be so interlocked with the switch that isolation is complete before the fuse enclosure can be opened; further the switch shall be prevented from closing while the fuse cover is open.

9.12 Starters

9.12.1 General requirements for motor starters

All starters to be used in the operation of pump motors shall be of the "soft start" type (autotransformer starters) and not D.O.L. starters or Star-Delta.

The starter cubicles are required to form part of a motor control centre and as such circuit connections, protection devices etc., shall comply with the relevant clauses of EN 60439-1 for form 3b switchboards. The cubicles shall be easily accessible for maintenance purposes and shall be damp and dust proof to IP54. Each motor starter shall be of a rating to carry the full load current of its rated duty at its most severe load conditions.

Motor starters shall be combination type as defined in and complying with EN 60947-4. Motor starters shall be of the electromagnetic non-latching type. Utilisation Category shall be selected to suit the application of the motor starter, but shall be not less than AC-3.

Unless otherwise specified, motor starters shall be suitable for uninterrupted duty. Motor starters shall have Type 2 short-circuit co-ordination. The circuit breaker fuse, contactor and overload relay combination shall have undergone and passed all the tests specified for full Type 2 co-ordination. Motor starters to be PLC controlled shall be adapted for such control.

Each individual starter shall be housed in a separate and totally segregated compartment of fixed or withdrawable type as specified in Particular Technical Specification and shall i.e. contain the following:

1 No. Three Pole and neutral (T.P. & N.) externally operated fault making, load breaking isolating switch interlocked with the cubicle door with provision for using a padlock to hold it in the "OFF" position only. Isolator handles shall not be removable. The isolator shall be provided with suitable number of auxiliary contacts.
1 No. T.P. & N. moulded case circuit breaker.

1 No. set of frequency converter as follows:

The frequency converter shall be delivered with the newest technology including digitised control system, menu programming, display for reading of faults and operation conditions.

The program system for the frequency converters shall be simple so that input of all data can take place without other equipment than the operation unit in the frequency converter. After programming of the unit, it must be locked with a code or similar.

It must be possible to read all alarms in a display or with lamps. Regardless of the type of fault that may arise, it must be possible to transmit this alarm via a joint fault signal to the SCADA system. In the event of critical faults in frequency converter, motor or pump etc., the frequency converter must cut out.

The frequency converter shall be protected against voltage surges, excess current, excess temperature as well as be secured against short circuits and earthing.

The frequency converter shall be delivered with an EMC filter.

Where two or more contactors are installed within a starter they shall be electrically inter-locked to ensure that the correct starting sequence is maintained. The following further devices are to be included.

- Power factor correction capacitor shall have protective fuses.
- Include adjustable time delay relay on sequence starting (0 ÷ 10 minutes).
- Provide normally open, volt–free contacts for local and remote indication
- Provide one set of normally open volt–free contacts for remote overload alarm indication
- Provide one set of terminals for remote emergency lock–off–stop and remote indication lamps.

The following equipment shall be mounted on the front of the starter cubicle door:

1 No. Ammeter in motor circuit, fitted with suppressed scale showing motor running and starting current.
1 No. kW meter in motor circuit, fitted with suppressed scale to read motor running and starting power. (For motors above 15 kW).
1 No. Pilot lamp “Motor in Operation”

“Motor in Operation lamps” shall be initiated by the final contactor stage.

1 No. Pilot lamp “Overload Tripped”
1 No. Overload reset pushbutton
1 No. “Off-Local-Automatic” selector switch.
1 Set. Stop/Start pushbuttons for operation under hand control.
1 Set Component labels.

9.12.2 Actuator starters

When motorised valves are specified, the actuator starters shall be integrally housed within the actuator in a robustly constructed, totally enclosed weatherproof housing to enclosure protection standard IP65. The motor starter shall be capable of starting the actuator motor under the most severe load conditions.

The starter housing shall be fitted with contacts and cable terminations for power supply, remote PLC control and positional indication circuits.
Each actuator starter shall be equipped as follows:

2 No. T.P. Magnetically operated line reversing contactors with arc chutes, no-volt releases and electrical and mechanical interlocks.
1 No. T.P. Thermal overload device.
1 No. Set of "Open", "Close" and "Stop" pushbuttons.
1 No. Set of "Torque", "Open" and "Close" position limit switches.
1 No. "Local-Off-Auto" Switch with padlocking Works. The "Auto" position will permit control to be initiated by a signal from automatic equipment as detailed in the relevant section of the Specification.

9.12.3 Automatic control

The motors in some applications will be required to operate in a predetermined sequence and starters should include suitable auxiliary relays and contacts. All starters which are not PLC controlled shall contain a timer, fully adjustable between 0-30 minutes, which shall only permit the drives to start in a staggered sequence on restoration of supply after an electricity supply failure.

9.12.4 Power factor correction capacitors

The power factor shall be corrected to 0.95 lagging for all motors rated above 10 kW. Unless otherwise specified in Particular Technical Specification, 3 phases unit power factor correction shall be provided for each motor circuit. On LV motor circuits the capacitors shall be housed in its respective starter compartment. Where due to space limitations the capacitors cannot be housed within the starters, they shall be installed in separate compartments adjacent to and fully interlocked with their respective starters.

The rating of capacitors shall be selected to correct the power factor of the motor when the associated drive is operating at its maximum duty point. Should the rating of the capacitor exceed 85% of the magnetising kVAR of the motor, it shall be switched by a separate contactor, interlocked and controlled automatically with the motor line contactor.

The capacitor(s) shall be connected after the line contactor but before the motor protection overloads, generally in accordance with the motor starter schematic diagrams. All capacitor circuits shall have three separate protection fuses housed within the respective starter compartments.

The capacitors shall be of the oil or synthetic mineral oil impregnated type with paper or paper and plastic, film dielectric in an oil tight steel tank complete with discharge resistances. A metal enclosed terminal box with a bolted or screwed cover shall be provided with cable entry sealing Works.

A label shall be fitted on all capacitors warning that discharge resistances are fitted. All capacitors shall comply with relevant standards. Capacitors containing polychlorinated biphenyls will not be accepted.

9.13 Electric motors

All motors, shall be furnished, adjusted and connected ready for safe operation. They shall be of approved manufacture and shall comply with the requirements of the specifications.
Motors of the same type and size must be fully interchangeable and shall comply, as far as applicable with IEC standard motor dimensions.

9.13.1 General requirements

Motors at 40°C ambient shall be of the squirrel cage induction type suitable for direct–on–line starting, with starting current not exceeding 6 times full load current unless specifically detailed in the relevant Section as an alternative arrangement.

Care must be taken in selecting the type of motor in relation to the starting characteristics of the driven load. Although a direct–on–line squirrel cage motor may be suitable in respect of starting current limitations, the starting torque may be insufficient and a motor of wound rotor construction (slip ring) could be required. Conversely, where a mechanical overload device is employed, it may be necessary to limit the starting torque of the motor thus ensuring the overload device can be set to give maximum protection to the plant.

All motors shall be suitable for operation at 380 V, 3 phases 50 Hz. supply and shall comply with EN or IEC Regulations and Standards.

Motor frames for indoor use shall conform to a degree of enclosure protection not less than IP54.

Motor frames for outdoor use shall conform to a degree of enclosure protection not less than IP55.

Totally enclosed motors shall be provided with means of breathing and drainage. Motor frames for submersible pumps submersible pumps shall conform to a degree of protection not less than IP68. All motors, exclusive submersible pumps, shall be suitable for operation in the site climatic conditions and in ambient temperature up to 40°C.

The rotors shall run in ball and/or roller bearings and the weight of the rotor shall be carried by ball thrust bearings incorporated in the motor body. Bearings shall have a minimum rated life of 6 years (50,000 hours) and have provisions for adequate lubrication.

The bearing caps on the non–drive end covers of the motors shall be arranged so as to allow a speed check to be taken. The efficiency and power factor of the motors shall be high over a wide range of load conditions and the motors shall be designed, manufactured and tested in accordance with relevant EN standards.

All windings shall have Class F insulation with Class B temperature rise limitations and this requirement is in addition to any adjustments necessary for the high ambient temperature at Site. A winding connection diagram shall be supplied permanently affixed to the inside of the terminal box or cover.

In addition to standard rating and performance data, motor nameplates shall include details of class of insulation, temperature rise and type of enclosure. Motors shall be S4 duty type and

capable of a minimum number of 15 starts per hour unless specifically detailed else-where in the appropriate section of the Specification.

The continuous maximum rating (C.M.R) of each motor shall be in accordance with the following requirements:

Application	**Up to 125 kW drives**	**Above 125 kW drives**
All pump motors (excluding positive displacement type)	10% above the calculated maximum power requirements under all conditions of operation	5% above the calculated maximum power requirements under all conditions of operation
Positive displacement pumps and compressors	25% above the calculated power requirements for nor-mal duty or 5% above the power required for maximum duty whichever is the greater	12.5% above the calculated requirements for normal duty or 5% above the power re-quired for maximum duty whichever is the greater
All other drives including screens, mixers, conveyors, tank scrapers, etc. and process plant	50% above normal duty requirements	25% above normal duty requirements

The above percentages shall be added to the calculated power requirements for motors, prior to making the necessary adjustments (increased ratings) for high ambient temperature at Site. A higher percentage shall be added to the calculated power requirements for motors, if specified in the appropriate machinery section of the Specification.

All motors shall be capable of developing a minimum starting torque of 150 per cent of the full load torque. It may be necessary, however, to limit the starting torque on some drives and this shall be achieved by the form of starter and method of starting.

The motors shall be commercially silent in operation and run free from vibration. The rotors shall be balanced both statically and dynamically and shall be tested and adjusted for dynamic balance both in an approved manner. The site rating and normal ratings of all motors together with all performance data shall be provided to complete all the various schedules of particulars.

All guaranteed and technical data shall be that for an ambient temperature of 35°C, although all proving tests at the manufacturer's works shall be carried out at ambient temperature. The declared site rating at 40°C shall be estimated by means of approved recognised methods, the manufacturer shall provide de-rating curves for each motor and these shall be included in the maintenance instructions. Where identical type and size motors are being supplied, one motor only shall be subjected to full tests and the remaining units to abbreviated tests.

Terminal boxes shall be provided with glands suitable for XLPE or insulated wire armoured, PVC sheathed cable. The motor stool base, where appropriate, shall be drilled at works, vertically below the terminal box gland for the passage of the cables and the edges of the hole slightly countersunk or the hole bushed.

Termination boxes and terminals shall be of suitable dimensions to accept appropriate over-sized cables in accordance with the schedules of particulars. All motors drives shall be la-belled to correspond with their respective starters.

Arrangements shall be made with the manufacturer so that the Engineer may witness motor tests if so desired. Triplicate copies of motor test certificates shall be provided for approval. Additional copies shall be provided and included in the Operating and Maintenance Instructions.

9.13.2 Protection of motors

For motors rated less than 0.5 kW, three single pole thermal overloads with phasing protection shall be provided.

For all motors rated above 0.5 kW three single pole thermal overloads and three single pole, wound magnetic adjustable overloads with phasing protection shall be provided or alternatively the motor shall be protected by a three phase motor protection relay.

9.13.3 Overcurrent and earth fault protection relays

Relays to be used for this duty shall incorporate selective Inverse Definite Minimum Time (I.D.M.T.) and Definite Time characteristics. Relays shall be arranged 2 pole overcurrent and 1 pole earth fault or 3 pole overcurrent and separate 1 pole earth fault to suit 3 phase 3 wire and 3 phase 4 wire system application respectively.

Inverse time characteristics shall be standard inverse or very/extreme inverse to meet the power system protection scheme requirements and shall fully comply with EN/IEC standards. Relays shall be of the static electronic pattern. Current and line settings shall be adjustable by integral switch or plug assemblies of approved pattern.

Relays shall be suitably rated to operate at the specified DC auxiliary circuit voltage and have output contacts suitable for operating the tripping mechanisms of the associated circuit breaker and initiating alarm and indication systems.

9.13.4 Direct motor thermal protection

Where specified, motors shall be provided with embedded thermal switches or thermistors with a protective relay operating in the contactor circuit. Thermistor protection on motors fitted with internal thermal devices shall be arranged such that in the event of device operation, a lock out function to prevent automatic re-start upon temperature reduction is operated. The tripped indication shall also operate.

Thermostat protection relays shall be ambient temperature compensated and have external manual reset Works.

9.13.5 Emergency stop push buttons

Emergency stop push buttons of the mushroom headed, stay put type shall be provided adjacent to all motors as specified in EN 418 and EN 1050.

Once operated the motor shall remain locked out until both the push button twist to release mechanism, and the "emergency stop reset" push button on the control panel have been operated.

The emergency stop push button shall be direct acting on the motor circuit, i.e. no intermediate devices shall be utilised.

Emergency stop push buttons shall be mounted on a suitable framework arrangement at a height of 1m and in a position to be accessible for emergency operation by the works personnel.

9.13.6 Name plates on motors

Manufacturer's name plates on electric motors shall contain at least the following information:

- Rated power (kW)
- Type
- Power factor
- Serial number
- Efficiency (%)
- Voltage (V), type of starting.
- No. Of phases
- Degree of protection
- Frequency (HZ)
- Type of construction
- Synchronous speed (rpm)
- Year of manufacture rated current insulation class
- Rated Current
- Insulation Class

9.14 Cables

All cables used in the construction of the electrical installation unless otherwise specified, shall be manufactured to comply with IEE regulations and the relevant National Standards:

All cables shall be of suitable voltage grade, with stranded copper conductors, selected for the climatic conditions specified and shall be rated by the approved factors laid down in the latest issue of relevant standards. The selection of all cables and rating factors shall be based on the followings:

- Ground Temperature.
- Thermal resistivity of soil.
- Cable depth L.V:0.7 metres
- Cable depth, Control and Instrumentation:0.7 metres
- Cable grouping in accordance with the relevant tables.
- Cable in air in accordance with the relevant tables.

Each cable shall be of sufficient rating for its duty under normal, fault and site installation conditions. To assess the rating and cross–section required for each cable, the following factors must be considered as a minimum:

- Fault level.
- Conditions of ambient temperature relevant to method of laying.
- Voltage Drop.
- Voltage drops in motor circuits due to the starting method.
- Over current settings of circuit breakers.
- Disposition of cabling, whether in air, ducts or trays/ladders.

Where cables are run in conduit any requirements of the EN standards must be complied with. Where a neutral conductor is required, its cross–sectional area shall not be less than that of the phase conductors, unless otherwise specified. Each and every mains supply cable shall be provided with an individual earth continuity conductor (PE), which shall be not less than that of the phase conductors, unless otherwise specified. The PE conductor can either be one core of a multicore cable or a separately run, PVC insulated (yellow–green) stranded single core cable sized in accordance with the EN standards. The use of cable armouring, conduits, water or other service pipes as the only means of an earth continuity path is strictly prohibited.

Each cable shall be supplied in lengths suitable for a continuous run, as no through joints will be permitted in any cable run without the prior consent and written permission from the Supervisor.

Prior to dispatch to site, the supplier shall pass to the Engineer, in triplicate, copies of the cable manufacturers test certificates for approval.

9.14.1 L.V. cables, General

All L.V. power cables shall be of the thermoplastic insulated type of either polyvinyl chloride (PVC) or cross linked polythene (XLPE). These shall be manufactured in accordance with VDE 0271 or DIN 46235. They shall be of 600/1000 V grade and comprise stranded copper conductor, PVC or XLPE insulated with suitable bedding, sheathed overall with extruded PVC. All L.V. cables shall be from an approved manufacturer.

9.14.2 L.V. cables small wiring

Small wiring cables for use on power, lighting, ventilation etc. shall be 600/1000V grade and a minimum conductor size of not less than 1.5 mm2 cross sectional area. All conductors shall be stranded.

9.14.3 Control and instrumentation cables

Control and instrumentation site cables shall be shielded and have polyethylene or PVC insulation. These shall be manufactured in accordance with VDE and IEC standards as IEC 227. Each cable shall have its individual cores identified along their entire length by permanently printed numerals or letters. At every point of termination, core identification shall be carried out using an approved system of ferrule markers. At points of interconnection of wiring at which a change of numbering is unavoidable double ferrules shall be provided on each wire.

Any change of numbering shall be recorded on the wiring diagrams of the equipment at which the change is made.

Where it is proposed to use junction boxes for the marshalling of control and instrumentation cables to a common item of equipment, etc., any such junction box shall be of the wall mounting type, purpose made, complete with double terminal blocks of the pressure plate pattern.

All incoming wires shall be identified with core ferrules in accordance with the system schematic and cable diagrams. Prior to the installation of any junction box, the Contractor shall submit to the Engineer full details of the box and proposals for its use and only commence installation on the receipt of written approval from the Engineer. Steel wire armouring is required for underground cables.

9.14.4 Cabling method for electrical power

Every cable shall be installed in accordance with the relevant codes of practice and shall be neatly run in all situations.

When more than one cable is to be terminated at an item of equipment, particular care should be taken to ensure that cables to that equipment are routed from a common direction and each is terminated in an orderly and symmetrical fashion. Each and every cable shall be permanently identified at each end by its cable number, as noted within the schedules. The identification label shall be of adequate size and style to a pattern approved by the Supervisor and shall be securely fixed to its relative cable.

Where cables enter or leave structures or panel plinths, the ducts shall be sealed at the points of entry or exit. Chaulking shall be carried out with an approved compound and followed by not less than 40 mm of epoxy resin, two mix–cold waterproof compound or a weak sand/cement mixture as directed by the Engineer. This shall include any spare ducts. The Contractor shall be responsible for temporarily sealing all cable ducts into structures during the installation stage to prevent accidental flooding of the structures.

During caulking care should be taken to ensure that the serving and/or armouring of any cable is not damaged. In the event of any armouring or serving fault being made it will be the responsibility of the Contractor to repair or make good any such fault to the satisfaction of the Engineer. Where any such fault occurs, these shall be made known to the Engineer and subsequently recorded on the final record drawings.

All power cables shall be connected to switchboards and the like, in such a manner that the correct phase sequence, phase number and colour coding are preserved throughout the systems. The PVC and XLPE insulated L.V. cables shall have their cores identified, as follows:

- No.1 Phase L1 (RED)
- No.2 Phase L2 (YELLOW)
- No.3 Phase L3 (BLUE)
- Neutral Black or N
- Earth Green or Green/Yellow

Single core power cables shall have their cores identified as follows:

- Phase Red or Brown
- Neutral Blue or Black
- Earth Green or Green/Yellow

All cable conductors shall be terminated in suitable copper lugs or brass thimbles using an approved compression tool.

Under no circumstances shall the use of hand crimpers be permitted. All cables shall be delivered on robust cable drums which shall bear the full details of manufacturer, size, length and insulation and shall be offered to the Engineer for inspection prior to installation.

Straight through joints will not be permitted except where a route length is in excess of a maximum drum length in which case the Engineer is to be notified. At the terminals of rotating machines, each cable core shall have core ferrules to match the notation of each connection terminal of each machine.

Wherever it is required to remove the PVC sheath of a cable e.g. at a point of termination, the minimum length necessary shall be removed and the exposed conductor, sheath or armouring shall be adequately covered by an adhesive PVC tape or a PVC sleeve.

All L.V. cables whilst on their drums shall be adequately sealed at each end against the ingress of moisture. When a cable is cut from a length on a drum the drum length shall be immediately sealed. All cables once cut and laid shall be terminated in their final position or effectively sealed. All cables shall be drawn from the top of its drum which shall be jacked and positioned for easy draw off in relation to its final position of installation, Where a long length of cable is drawn from its drum, cable rollers or skid boards shall be used.

The general routing of cables shall be as generally indicated on the Contract drawings but the final routes shall be those agreed with the Engineer prior to any cable installation work being carried out. All cables shall be installed in strict accordance with the requirements of this Specification.

9.14.5 Cable trench work

The Contractor shall prepare drawings giving the exact requirements for all cable trenches, detailing the width and depth of each trench and detailing road crossing cable ductwork to be provided. The drawings shall be prepared in conjunction with the Engineer and shall be approved in writing before issue to site.

The excavation and back filling of cable trench work shall form part of the work by a civil works contractor together with the supply and laying of road crossing and other ducts. The Contractor shall work closely with the excavating and back filling contractor (the civil works contractor).

The laying of all cables shall satisfy the following requirements:

- Cable depths shall be assessed from the finished ground level unless otherwise directed by the Engineer.
- Before laying in cables the Contractor shall inspect the trench work to ensure that the trench bottom is of a smooth and firm contour and free from broken stones or rocks.
- Cable bedding within the trenches shall be formed by a 75 mm sand layer.
- Cables shall be laid with adequate separation and shall be “snaked” to avoid tension during backfilling operations and subsequent settlement.

- Before sanding and backfilling, all laid cables shall be inspected by the Engineer and a further inspection made following sanding and tiling.
- After cables have been laid, they shall be covered by a further 75 mm of sand which shall be well tamped around the cables.
- After sanding, concrete cable covers and red warning tapes shall be placed as required.
- The civil works contractor shall carry out backfilling and the Contractor shall ensure that cable covers are undisturbed and that large rocks, stones and the like are eliminated from backfill spoil.

9.14.6 Cable tray work

The Contractor shall supply and erect all required cable tray work.
The following points are to be taken into account in selecting routes for cable trays:

- Number of drive, power and control cables to be located on each cable tray.
- Separate cable tray works for machinery (EN 60204-1) and building installations (IEC 364)
- The avoidance of existing pipework and pipework required for future extensions.
- The avoidance of maintenance areas of machinery, pipes, etc.
- The avoidance of unnecessarily long runs of cable.
- Tray runs to be at high level as far as possible with droppers to plant items.
- The tray to be arranged vertically as far as possible.

The cable tray shall be manufactured from heavy duty, hot dip galvanised mild steel complete with approved type fixings and installed in accordance with manufacturer's instructions to permit maximum expansion.

Support brackets shall be constructed from galvanised steel, heavy duty type, and installed at a maximum of 1,200 mm centres. Fixings of these brackets will depend on the tray loading. Bends, tees and junction pieces shall be of standard design and have an inside radius of not less than 300 mm.

The trays shall be of adequate width for cables to be laid flat and not bunched. All cables shall be saddled or cleated in position as they are installed along the route. Cables on vertical trays shall be securely fixed at 600 mm maximum spacing. Cables on horizontal trays shall be fixed at suitable intervals to ensure a neat and orderly installation.

Particular care should be taken on vertically rising tray work, and adequate cable fixings shall be supplied to ensure security and distribution of load.

9.15 Building works

The Contractor shall be required to mark out all necessary holes and chases in the course of carrying out the installation and be responsible for the correct positioning of all fixings. All cutting away and grouting in of fixings in brick and concrete work and the making good shall be carried out by the Contractor. The Contractor shall arrange for the general requirements necessary for the electrical installation such as floor ducts, chases, etc., to be carried out at various stages of building work to ensure continuity of construction. In all cases the Contractor shall drill and plug walls, ceilings, floors, etc., and provide any special fixings for securing conduits, cables, etc.

9.15.1 Conduit systems

Approved conduit systems shall be rigid steel conduits with metric threads and for flexible steel conduit and adapters, as appropriate. All rigid steel conduit and fittings shall be screwed and hot dip galvanised, inside and outside.

In all plant buildings and structures, conduit shall be fixed to the surface of the wall or concealed in the floor screed when they cross the floor. Conduit shall be concealed in those lo-cations where the wall or ceiling finishes as shown on the drawings or detailed in specific clauses make this possible.

All conduits shall be installed in an approved manner and arranged with adequate ventilation and drainage where necessary. Where practicable, all bends or sets, shall be formed in the conduit itself. Inaccessible junction boxes shall not be used.

The whole of the conduit system shall be completely swapped through to remove any loose matter or dirt before cables are drawn in. Where conduits connect to switch boxes, draw-in boxes, etc., the conduits must have a machined faced socket, screwed on to the end which when tightened, is flush with the outside of the box. The conduit is then to be secured to the apparatus by means of a hexagon smooth bore brass bush screwed from the inside of the apparatus into the conduit socket, in order to make a sound and tight mechanical joint. Conduits secured by locknuts in plain drilled holes will not be permitted.

All exposed threads shall be cold galvanised after installation. Surface run conduits shall be supported at intervals in accordance with the following schedule:

Size	Interval
20 mm	1.2 m
25 mm	2.0 m
30 mm	2.5 m

Where bends and sets occur in the conduit run, the conduit shall be securely fastened at a distance of 250 mm on either side of the diversion. Standard junction or adaptable boxes shall be provided at all junctions and at sharp changes of direction, in addition to any special positions where they are called for by the Engineer. Steel or malleable cast iron inspection couplers may be used in long runs to facilitate drawing in cables.

Only continuous lengths of buried conduit shall be installed between boxes, no joint boxes being allowed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture, with an earthing clip at each side of the coupling, connected by the correct size of tinned copper stranded wire.

The ends of conduits laid or set in shuttering prior to concreting, shall be temporarily sealed off with a coupler and a solid brass plug. Installations of conduits shall be made on the exterior surface of buildings shall be done only after acceptance of the Engineer.

Fixing to surfaces of walls shall be by means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in construction floors they shall be held in position with substantial fixings of make and pattern approved by the Engineer.

Conduit shall be of the screwed pattern galvanised by the hot dip process. All conduit fittings not carrying accessories shall be supplied with flat covers, fixed in position with round head brass screws. Each fitting shall be supplied with a neoprene gasket.

Adaptable boxes shall be constructed of minimum 3 mm sheet steel or best quality cast iron, finished as previously detailed for conduit fittings and sized to prevent the undue packing of cables.

Weather proof boxes and accessories shall be used outdoors, and where indicated in the Specification. Conduit shall be installed such as to permit complete rewiring, without the need to carry out builders works. No single conduit serving single phase socket outlets, lighting points and switches shall contain more than one phase.

9.15.2 Flexible conduits

Where the conduit system terminates at any equipment requiring a non–rigid connection, a flexible conduit shall be installed of the PVC or PVC sheathed metallic type, fully watertight with purpose made connection adapters.

Each flexible connection shall include not less than 400 mm length of flexible conduit.

9.16 Lighting and socket outlets

9.16.1 Lighting switches

Indoor surface switches shall be of minimum enclosure standard IP44. Where appropriate, they shall be of the multiple phase type and where possible shall be arranged in multi–gang boxes.

Outdoor lighting switches shall be of minimum enclosure standard IP54. Rear entry shall be provided to allow concealed conduit installation. Switches for flush mounting shall comply with local standards.

Switches controlling fittings in toilets, washrooms, bathrooms, etc., shall be suitable for ceiling mounting, pull cord operated or shall be in accordance with this clause and installed out-side the rooms.

Special care shall be taken to ensure that all switches are securely fixed, truly vertical and that flush mounted switches are flush with the wall finish so that the overlapping cover plates seat on to the rims of the boxes.

9.16.2 Lighting fittings

Lighting fittings shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with flexible cables of a mini-mum conductor size of 1.5 mm² insulated with silicon rubber or PVC. Break joint rings shall be used in conjunction with batten holders, ceiling roses or back plates mounted on to a flush installation.

Standard fluorescent lighting fittings shall have two suspension fixing points. All lamp holders for flexible pendants shall be of the all-insulated skirted pattern with cord grips suitable for batten or wall mounting and shall be of similar pattern. All lamp holders shall be of the Edison screw pattern.

All fluorescent tubes shall be of an approved manufacture and standard white. They shall be suitable for the lighting fittings in which they are installed and of correct voltage. All incandescent lamps shall be of an approved manufacture with metal coil filaments, gas filled, clear finish in all standard sizes with standard caps to suit the fittings in which they are installed.

The Contractor shall supply and install all lamps for the entire lighting fitting installation, and shall replace all burned out lamps up to the time that the Engineer takes final acceptance of the Works. The lighting layouts and fittings shall be approved by the Engineer.

9.16.3 Socket outlets

Socket outlets for installation in plant areas shall be manufactured by an approved manufacturer and in accordance with relevant Nationals Standards. Casings shall be produced from a thermoplastic material suitable for industrial application.

220 Vt sockets, shall be non–switched, 10 A 2 pole & PE and IP 54
380 Vt sockets shall be switched, mechanically interlocked, 16 A 3 pole and neutral and PE. Protection enclosure IP 54.

9.17 Control cabinets and distribution boards

9.17.1 Control cabinets

Where local starter panels are called for, each shall be provided with a fully metal or rein-forced glass fibre construction cabinet. The cabinets shall be adequately sized to house the respective panels and be provided with front opening, hinged, lockable, access doors. Back panels shall be of a durable material. The base of the cabinet shall be complete with a gland plate and the necessary ventilation devices. Construction shall be to a minimum of IP54. The requirement of control cabinets shall be approved by the Engineer.

9.17.2 Distribution boards

All distribution boards shall be of totally enclosed, metal clad pattern, manufactured in accordance with IEC 439-3. The enclosure shall be made from zinc coated mild steel sheet formed to a clean line and complete with a lockable hinged cover with gasket. Removable plates with conduit knockouts shall be provided at top and bottom.

The maximum height of any operating controls shall not exceed 1,700 mm above finished floor level. All distribution boards shall be complete with an isolator of the rating and phase as the fuse switch at the supply source.

Doors shall be fitted with suitable gaskets and shall be easily removable to preserve the finish and simplify installation. Each distribution board shall be arranged for top or bottom cable entry

and shall be provided with ample cable termination plate and chamber, to enable cables to be neatly glanded with tails grouped and terminated on to the appropriate internal terminations.

Distribution boards shall be wall or floor mounted and shall, when specified, incorporate on-load incoming supply switch disconnectors complying with EN 60947-1 which shall be of the front-of-panel operated type, with an "ON/OFF" indicator and capable of being padlocked in the "OFF" position. Distribution boards shall incorporate cartridge fuses, or combinations of single pole and neutral and triple pole miniature circuit breakers.

Miniature circuit breakers (M.C.B.'s) shall comply with relevant EN or IEC standards. They shall be fitted with thermal overload and instantaneous magnetic short circuit protection. Earth leakage protection, when specified, shall be current operated.

Back-up fuses shall be fitted to provide the specified rupturing capacity, but the ratings of the M.C.B.'s must be correctly co-ordinated with the fuse rating to achieve the necessary degree of discrimination.

Each bank of M.C.B.'s/fuses shall be clearly identified with its appropriate phase reference/code, and the mounting framework for the banks of M.C.B.'s/fuses shall be easily removable to simplify installation. Adequate phase barriers and shields shall be fitted to ensure that after installation and wiring, all bare terminals and wires are covered, to prevent accidental contact with live conductors during the normal procedure of fuse changing and resetting of M.C.B.'s.

All neutral bars shall have a separate terminal for each fuseway within the distribution boards.

9.18 Earthing

9.18.1 General requirements

The metal framework of all electrical and associated equipment, exposed building steelwork, metal enclosures and associated screenings, supports, doors and any other metalwork that is not normally used to conduct electricity shall be effectively earthed at all times. Particular care shall be taken where moving parts are involved that they are earthed in any normal position, e.g., circuit breaker carriage, cubicle or substation door. A suitable flexible connection shall be provided for continuity between each and every moving part.

9.18.2 Earthing systems

A main earth terminal bar shall be provided for each earthing system of each section of the power system or building installation to which all main earth conductors, earthing leads, neutral earth connections, switchboard earth bars, frame earths, and electrode nests, etc. shall be connected. Connections shall be readily accessible for test purposes.

Each main earth terminal bar shall comprise a wall mounted mild steel channel supported on non-ceramic insulators and of a length to accommodate all connections.

Earthing and equipotential bonding conductors of each earthing installation shall be a ring or radial system and shall be adequately sized for maximum fault current and the minimum cross section requirements of main earthing systems shall be 25 mm^2.

The armour wires on main cables shall be solidly bonded and earthed to provide additional earth paths. Particular care shall be taken on cable termination boxes, to ensure that the cable armour is adequately bonded to the associated item or plant.

Particular care shall be taken to ensure earth continuity across items of equipment situated within a cable run. Should the design of such equipment not give an adequate and lasting continuity through its structural body, then additional earthing clamps and conductors shall be provided to independently bond the cable sheaths together.

Joints and terminal boxes in underground cables (if approved by the Engineer) shall be bridged by tinned copper of adequate cross section, bonded to the cable sheath. Earthing systems shall be performed according to National standards.

9.18.3 Protection of earthing systems

The complete earthing system shall be protected against damage by corrosion where necessary.

9.19 Lightning protection

9.19.1 Structures and buildings

All structures and buildings shall be provided with lightning protection in accordance with relevant EN/IEC and local Standards. Each structure shall be provided with one or more lightning arresters mounted at the highest point. Lightning conductors shall be routed as directly as possible avoiding acute bends. The installation shall generally comply with the requirements for earthing conductor installation.

9.19.2 Lightning protection devices for plant

The contractor shall provide lightning and surge protection devices at each area of plant as detailed in the particular specification. This shall ensure isolation and automatic resetting of the parts of the system being subjected to high surge currents, devices shall be unfused.

Lightning protection shall be selected to provide the highest degree of protection possible, for the circuit being protected, i.e. the clamp voltage shall be the lowest possible commensurate with normal operation of the circuit. The type and manufacture of the Lightning Protection Unit shall be approved by the Engineer.

Each lightning protection unit shall be earthed to an individual earth electrode, as directly as possible, without inductive loops and equipontial bonding to the nearest earth reference bar. A single unjointed earth cable shall be utilised.

Individual lightning protection units shall bolt directly onto a lightning earth bus bar. Cables and cores containing the circuits to be protected shall not be looped or grouped together until the circuits subject to induced lightning energy have passed through the protection units.

Where two or more lightning protection units are mounted on the same rail mounted earth bar, the earth cable shall be sized as follows:

•Cable length less than 6 metres 10 mm2
•Cable length greater than 6 metres 16 mm2

The whole assembly shall be mounted inside an insulated box, if not already mounted separately from other equipment, close to the chosen earth termination in order to achieve a short, straight connection.

Lightning protection units which are mounted in an enclosure supplied with an ac electrical power supply which utilise DIN rail mounted earth bars shall have the earth bars insulated by means of a proprietary standoff, or the DIN rail insulated in an approved manner from the electrical power earth or any earthed conducting surface.

The route for the earth conductor system shall be as far away as possible from the vicinity of signal- and LV cables. The earth conductor shall be copper, no smaller than 16 mm² in section, and its route shall be as short and direct as possible, in any case no longer than 10 metres. The cable run shall be straight, but any bends that are necessary shall have a long radius.

The earth termination and the method of connection shall be approved by the Engineer.

9.19.3 Earth electrodes

The contractor shall provide an earth electrode system in each cases where lightning protection unit, Motor Control Centre, control board, distribution board etc. provides for the facility of lightning surge diversion equipment. The system shall be equipotential bonding to the main protective conductor system at the common point of connection of the distribution system which it serves.

Earth electrode systems shall be provided where specified in the particular specification. Where lightning protection is specified to be provided, the contractor shall provide an earth electrode system in full accordance with the relevant code of practice.

9.19.4 Earth electrode installations

Earth electrode installations shall connect earthing conductors to the general mass of the earth. The installation shall comprise earth rods, mesh or a combination in order to obtain the required earth electrode resistance.

Earth rods shall be of proprietary manufacture 16 mm outer diameter, made up of sections of 1.2 m long with internal screw and socket joints and fitted with a hardened steel tip and driving cap. They shall be driven into the ground to a minimum depth of 2.4 m.

A minimum of two earth rods or other electrode shall be provided by the contractor for each main earthing system, and the conductor brought back to the main earth bus-bar for each.

Connections to the electrodes shall be made as to be easily accessible for periodic inspection and shall be protected against mechanical damage and corrosion. The actual connection to the earth rod shall be by means of a purpose made non-ferrous clamp and shall be made below ground level, in a concrete inspection pit, having a removable cover.

When the installation has been completed, soil resistivity or other tests shall be carried out and witnessed by the Engineer, in order to ensure that the required earth loop impedance figure of less than 5 ohms is attained.

9.20 Labels, Marking

All external and internal labels shall be engraved multi-layered plastic affixed with chrome plated screws. Each switchboard, control panel, distribution board, compartment door, etc., shall have a title label and each door mounted component or control shall have a function label.

Every internal component shall be identified and each fuse shall be labelled with identification, fuse type, fuse current.

Compartments with doors not interlocked to an isolator or removable covers having access to live parts shall have an external label affixed thereto: -"DANGER LIVE TERMINALS" - black letters on a yellow background.

A list of label inscriptions shall be submitted to the Engineer for approval before manufacture.

9.21 General Instrumentation, Monitoring and Control Requirements

9.21.1 General

The Clauses in this Section define the general requirements and standards of workmanship for the manufacture, supply, installation and commissioning of all instrumentation, monitoring and control equipment (excluding switch-gear and motor control centres) and shall be applicable to these Works unless stated to the contrary in the application clauses.

9.21.2 Contractor's Responsibility

The Contractor shall be responsible for:

- all aspects of design, application and, where applicable, subsequent operation of the equipment, monitoring facilities and control circuits in accordance with the requirements of this Specification,
- liaison between sub-contractors to ensure complete compatibility of all equipment at both component and system interface levels,
- overall systems Engineering to ensure that all equipment, components and systems together form a consistent, rational and fully integrated instrumentation, monitoring and control installation,
- ensuring that each system is handed over complete in all detail and in perfect working order,
- the supply and installation of all components including signal isolators, amplifiers, converters, filters, line/equipment protection devices, voltage stabilisers, inverters, power supplies and similar items which may be necessary to achieve the correct functions as specified in the application clauses and to provide a safe and reliable installation; whether or not such items are specifically called for in the Specification,
- providing protection on all relevant circuits and equipment against the effects of lightning and other induced voltages.

- •the supply and installation of all interlocks, alarms and other facilities as the Engineer, may consider necessary to ensure safe and efficient operation ensure safe and efficient operation whether or not such items are specifically called for in the Specification.
- The approval by the Engineer of any drawing shall not absolve the Contractor from his complete design responsibility. All the Contractor's proposals and working drawings for and in connection with the Works shall be submitted early in the Contract period to facilitate co-ordination with Contractors of other trades.

9.21.3 General design requirements

The equipment shall be guaranteed suitable for operation under the prevailing environmental conditions and shall be designed:

•such that routine and occasional maintenance throughout its life shall be a practical minimum, compatible with the preservation of maximum reliability,
•to withstand the electrical, mechanical, thermal and atmospheric stresses to which it may be subjected under operational conditions, without deterioration or failure,
•and constructed to the highest available standards of manufacture, reliability, accuracy and repeatability.

Where more than one component or item of equipment is supplied to perform a particular function, all such items shall be identical and interchangeable. The degree of protection for equipment enclosures shall be in accordance with IEC 529 as follows:

- IP54 for indoor applications,
- IP65 for outdoor applications,
- IP68 for transducers and other equipment mounted within valve or meter chambers or similar locations.

All equipment cabinets shall have lockable doors and any ventilation openings or louvres shall have effective dust filters. Any cooling fans shall have fan failure alarm contacts connected into the relevant alarm system.

External equipment shall be protected from direct sunlight by a well-ventilated cabinet, canopy or other approved type of sunshade. Equipment in air-conditioned locations shall be rated for continuous operation in ambient temperature up to 45°C. External equipment and internal equipment not in air-conditioned locations, shall be rated for continuous operation over the ambient temperature range 0°C to 50°C. The above temperatures make no allowance for local temperature rises due to operation of the equipment itself or by adjacent equipment.

All equipment shall be protected against aggressive and/or corrosive environment. All instruments shall be installed in the locations shown on the Contractor´s drawings and where connections are to be made into pipelines, each installation shall be complete with the necessary manifolds, isolating valves, drain valves, test points, sample cocks, etc., as appropriate. In all cases it shall be possible to isolate and remove the instrument, and fit check gauges, or take samples as appropriate.

All analogue transmitters, receivers and direct wire transmission systems shall have a signal level of 0/4–20 mA or 0–10 V. All panel indicator lamps shall have a lamp test facility.

9.21.4 Installation approval

Where there is no detail in the Specification or associated drawings regarding the exact location or method of installation of measuring equipment, sensors, or other site mounted equipment, the Contractor shall submit details of his proposed installation to the Engineer for approval and obtain this approval before starting any installation work.

9.21.5 Testing and commissioning

All equipment, including panels, consoles, pillars and all separate items shall be subject to inspection and full function test at the manufacturer's works. All equipment, sequences, programs and the like shall be proved and demonstrated to the Engineer as being in accordance with the application requirements.

Test Certificates, including characteristics covering the full operating range of measured variable against output signal, shall be provided for all instruments or sets of equipment measuring primary quantities.

Site testing shall include demonstration of the satisfactory operation of each system individually and the complete system as whole, before the start of main plant commissioning.

As an integral part of the setting to work and commissioning procedures, the Contractor shall ensure and demonstrate, to the Engineer's approval, that all items of equipment incorporating any form of variable setting (level electrodes, float switches, transmitters, trip amplifiers, meter relays, controllers, timer etc) have been adjusted to achieve optimum control of the process or plant operation.

9.21.6 Cables and cabling

All cables necessary for the complete installation shall be provided and installed in accordance with the requirements specified above.

All signal and control cables shall be shielded. All signal and control cables for PLC shall be shielded.

All multi–pair cables, except those connected to remotely controlled actuators, shall include a minimum of 25% spare cores. This spare capacity shall be over and above any cores which may be required for proposed future installations or extensions. Spare cores in addition to the above may be required in some cables to cater for the spare alarm channels.

There shall be a separate multi-core cable between each motorised valve actuator and the local distribution enclosure or control panel. All such cables shall include a minimum of 2 No. spare cores except those associated with actuators having remote control which shall have a minimum of 12 No. cores. All cores, even spare cores, in the cables shall be connected to terminals in both ends.

9.21.7 Instrumentation and control

All instrumentation, monitoring and control circuits and equipment shall be supplied at a voltage not exceeding 55 volts to earth. These supplies shall be from one of the following:

- a battery/charger unit, typically of 24 V nominal output, but under no circumstances exceeding 48 V nominal output,
- a double wound transformer having a fused primary, a 55–0–55 V secondary with the centre point earthed and each secondary line fused,
- a transformer/rectifier system, comprising a double wound transformer with a fused primary and a secondary having one end earthed, together with a full wave rectifier unit incorporating voltage stabilisation if necessary. The mean voltage of the rectified output shall not exceed the nominal output from the instrumentation battery/charger units.

Equipment such as battery/chargers, no break and control power supplies, inverters etc. shall be supplied as necessary to maintain the required electrical supplies to essential instrumentation, monitoring and control systems which are to be kept in operation during a mains power failure. The essential equipment to be maintained during a power failure shall include mimic diagrams, alarm systems, data acquisition equipment and flow measuring, indicating, recording, integrating equipment or as otherwise detailed in the application clauses.

9.21.8 Remote control supplies

On remote control/indication circuits (such as occur with valves, penstocks, etc.) DC voltages and relays shall be used in all cases where the cable capacitance could be of sufficient magnitude to maintain AC relays in an energised state. The Contractor shall be responsible for establishing where such DC operation of control/indication circuits is required and for providing a suitable supply at locations where instrumentation battery/charger supply is not avail-able.

9.22 Construction of panels

All panels, cubicles, cabinets, consoles, and desks together with any other types of enclosure (excluding motor control centres and switch-gear) which form part of the instrumentation, monitoring and control installation shall comply with the specified in the clauses above covering panel wiring, equipment and terminals.

Removable earthed, metal gland plates shall be provided to accommodate all incoming/outgoing cables, and shall be fitted not less than 250 mm. above the floor level. All equipment, other than front of panel items, shall be mounted on racks or fixing bars and not directly onto the panels.

Each enclosure shall be vermin proof and dust proof with the necessary provisions made for natural or forced ventilation. All panel construction and arrangement details shall be ap-proved before manufacture, and panels shall be subject to inspection.

9.22.1 Panels for indoor use

All instrumentation, monitoring and control panels, designed for use within buildings shall be constructed of prime quality, cold rolled and annealed mild steel or zinc coated sheet steel, of adequate thickness welded and braced to form a rigid structure. The minimum sheet steel thickness shall be 1.6 mm, panel fronts and desk tops having not less than 2,0 mm to provide

the necessary strength to prevent bowing. Panel fronts shall be flat and free of bow and ripple. External corners and edges shall be rounded to give a smooth overall appearance. No design involving the use of externally visible assembly bolts or screws will be accepted. All floor standing enclosures shall be constructed with a 60 mm. deep plinth arranged to provide a recessed kicking strip at the front.

Equipment mounting panels shall be not less than 2 mm. thick and shall be strengthened and/or braced to avoid any distortion or vibration. Equipment mounting plates and brackets shall if necessary be hinged to provide quick and easy access to equipment securing screws, terminals and wiring.

Doors and access panels shall be adequately braced or strengthened to avoid any buckling or twisting. Doors shall be of folded and welded construction mounted on lift–off hinges, with one hinge engaging before the other. Where necessary, removable access covers secured by quick release fasteners shall be provided. All doors and access panels shall close onto neoprene or soft rubber sealing strips which shall be held in place mechanically and not by adhesive. All doors shall be lockable. Where "walk–in" panels or structures are provided, these shall be fitted with lockable car type handles operable from inside even when locked.

Surface preparation and finish shall be in accordance with relevant EN standards, with all internal surfaces finished in white. The external colour shall be as advised by the Engineer. The design and construction shall be such as to provide an enclosure of superior quality which shall match all other panels in the same location in style, appearance and finish, and have environmental protection to IP54. In cubicles for PLC (Programmable Logic Controllers) the temperature shall be between + 10°C and + 30°C. The relative humidity shall not exceed 85%.

9.22.2 Panels for outdoor use

All instrumentation and control cubicles, kiosks etc. designed for use outside shall be manufactured having walls of double skinned, resin bonded fibreglass, with a totally encapsulated infill of non-corroding alloy.

Box section steel shall be encapsulated into door edges and door frames. Hinges shall be of high tensile, non–corroding alloy with stainless steel pins and through fixing bolts. Large plane surfaces shall have adequate reinforcing to ensure rigidity.

The doors shall be complete with latching handles and locks. All door catches and locks shall latch onto steel reinforced surfaces. The door sill shall be protected by a non–corroding alloy material. The laminate material shall have flame retardant and shall retain "stability, integrity and insulation" for 30 min. when tested. An indicative fire test report shall be provided for approval of the Engineer.
Colour impregnated gel coats backed by coloured resin shall be used to ensure maintenance free and "colour fast" finishes. The finish colour, both internal and external shall be gloss white. Door mounted meters and transparent windows shall be of glass, which shall be protected from harmful direct sunshine by orientation or other approved means.

All internal equipment shall be mounted on supports built into the fibreglass structure. Fixing bolts through the skin will not be accepted. Each cubicle shall be constructed to provide environmental protection to IP55.

9.22.3 Panel wiring and equipment

The requirements of this Clause shall apply to all cubicles, desks, cabinets, mimic diagrams etc. being provided as part of the instrumentation, monitoring and control installation, but not motor control centres or switch-gear.
Panel wiring shall be carried out using cable to the appropriate British Standard, installed in a neat, systematic manner, securely fixed and supported on insulated cleats or trunking, and arranged so as not to impede access to any internally mounted equipment. Analogue signal cables and DC control cables at voltages not exceeding 48 volts (nominal), may be run together in the same cable bunch or trunking; but these cables shall be run separately from all other cables. In any cubicle, panel, or structure which is not fully enclosed (such as some mimic diagram structures), all cabling which is or may be at a voltage in excess of 55 volts (nominal) to earth, shall be run in conduit.

For all cables, the sizing shall be fully adequate for the possible maximum loading, and derating shall be applied as appropriate for cable bunching and ambient temperature. Identification ferrules shall be fitted to both ends of all wires, and shall be of the full circle type, threaded onto the cable such that all numerals are in line, and read outwards from the terminal.

Where stranded conductors are used, each end shall be fitted with a sleeved termination lug.
Terminations shall be restricted to one wire per terminal. Cabling to door mounted equipment shall be protected in flexible cable conduit(s) and cleated to form a loom with a loop of adequate length to allow easy door opening without causing strain to the components or cable.

Sharp edges of cubicles, trunking, components etc., which may be in contact with cables, shall be protected to avoid damage to cable insulation.

9.22.4 Panel protection

All terminals and all live parts (on equipment) which are or may be at a voltage in excess of 55 V (nominal) to earth, shall be enclosed by a protective cover, and carry a warning label stating the actual voltage.

For panels and enclosures covered under this section, the maximum potential between any two points within the panel or enclosure shall not exceed 250 V. Terminals and equipment which are supplied from other sources and which may remain live when the panel isolators are opened, shall be adequately protected and clearly labelled to this effect.

Adequate fuse protection for circuits and sub–circuits shall be provided and arranged such that any fuse failure causes the minimum disruption to controls and indications, and that any such fuse failure cannot create an unsafe operating condition. Fuses shall be of the HRC cartridge type and be mounted within fuse carriers. Ceramic fuse carriers and bases will not be accepted. All neutral links shall be bolted connections.

9.22.5 Panel earthing

A copper earthing bar shall be provided and bonded electrically to the main frame. It shall be provided with suitable brass screw terminals for the connection of the metal cladding, instrument frames, gland plates, cable tray, the armouring of all incoming cables and the site earthing system.

9.22.6 Panel heating

Each enclosure shall be fitted with one or more heaters to prevent condensation and assist ventilation. The heaters shall be so arranged and located that no deterioration can be caused to any equipment or wiring. The surface temperature of any part which may be accidentally contacted shall not exceed 65°C. The heating circuit shall be supplied via a fuse, an isolator and an Off/Auto switch. In the "Off" position the heater shall isolated and in the "Auto" position the heater shall be controlled by a thermostat or humidistat. All switches and controls shall be mounted within the enclosure.

9.22.7 Panel equipment

A fuse and isolating switch shall be provided for each incoming AC and DC supply. Where instrumentation, monitoring or control equipment is to be operated on AC supplies derived from within the cubicle, a 110 V (55–0–55) control transformer (or transformers) shall be provided for this duty. Each micro–processor and/or programmable logic controller shall have its own control supply transformer.

Each cubicle other than terminal enclosures shall be complete with a distribution unit providing an adequate number of fused outlets at 110 V (55–0–55) for possible future requirements.

Cubicles for PLC shall be equipped with a two-way outlet 220 V, and a fluorescent lamp 18 W, automatical switch-on when the door is open. Both the outlet and the lamp shall be fused in the LV distribution board.

All items of equipment mounted within the enclosure such as relays, electrical transducers, indicators, recorders, switch fuses, terminals etc. shall be arranged so as to provide easy access, be securely fixed and clearly labelled as to their function, designation, and where applicable, the voltage. Where meters and recorders are mounted on vertical front panels, the height of the instrument centrelines shall be within the following limits above finished floor level:

•Indicating meters: not less than 1.35 m but not exceeding 1.90 m.
•Recorders: 1.45 m but not exceeding min. and 1.85 m.

9.22.8 Terminals and termination

Terminals for the connection of all incoming/outgoing cables shall be provided and comprise anti–tracking mouldings of melamine, phenolic or comparable material fitted on a purpose–built mounting rail. The conductors shall be secured by screw clamps or bars, but not pinch screws.

All terminals used on circuits not exceeding 55 V (nominal) to earth, excluding power supplies and auxiliary drives, shall be of the disconnecting link type. Every terminal shall carry a clear identity number. Terminals at different voltages shall be grouped separately, and each group shall be clearly labelled with its respective voltage and function. Each group shall be segregated with a propriety barrier to give a physical separation of 2 mm minimum.

Transparent protective covers complete with a voltage warning label shall be provided on all terminals which are, or may be, at a voltage in excess of 55 V (nominal) to earth.

Sufficient terminals shall be provided for terminating all cores of all cables (including spares) associated with the particular enclosure. The number of terminals shall be sufficient to cater for all anticipated requirements plus 20 per cent spare terminals and 30 per cent spare terminal rail. A minimum of 5 terminals and 50 mm of spare terminal rail shall be provided.

Terminals for connecting to incoming/outgoing cables shall be mounted vertically wherever possible, arranged to provide easy access and to enable ferrule numbers to be read without difficulty. Direct termination onto such equipment as distribution boards, fuses or miniature circuit breakers is not acceptable. Terminal rails shall be backplate mounted only, the mounting of terminal rails on the sides, bottom or top of cubicles shall not be allowed under any circumstances.

9.22.9 Labels

All external labels for panels and other items where specified shall be clear perspex, back engraved, filled and back painted the same colour as the panel. All labels shall have chamfered edges and shall be fixed with chrome plated screws or adhesive with two-component glue (epoxy).

All internal labels shall be engraved multi–layered plastic fixed with chrome plated screws. Every internal component shall be identified and each fuse shall be labelled with the identification reference, fuse type and fuse current rating.

Panels with doors not interlocked to an isolator giving complete protection shall have a label affixed to the door: "DANGER LIVE TERMINALS" with black letters on a yellow background. The relevant voltage shall be stated.

All labels shall be in Swahili and English. A list of labels with Swahili and English inscriptions shall be submitted to the Engineer for approval before manufacture.

All socket outlets shall be clearly labelled to indicate their respective operating voltages. All junction boxes shall be clearly labelled to indicate the relevant cable reference numbers.

9.23 Batteries and Chargers

9.23.1 Control battery / charger equipment

This Clause covers the requirements for batteries and chargers, specified in the application clauses for the operation of control, instrumentation, alarm and monitoring equipment, but not for switch-gear tripping/closing batteries or other special function batteries.

Where alternative AC supplies are available, provision shall be made for taking the supply to the battery charger from either source (e.g. from either side of the bus–section switch) with facilities for automatic change over from one source to the other in the event of failure of the supply source.

The battery and charger unit shall where possible form a composite unit and be housed in a single sheet steel, floor standing cubicle having adequate ventilation and separate compartments for the batteries (lower compartment) and chargers (upper compartment). Access to the batteries shall be via lockable, hinged doors, and to the chargers via removable covers.

9.23.2 Batteries

The batteries shall be of the nickel cadmium type having alkaline electrolyte with a nominal output of 24 V, and shall be of adequate capacity to maintain full operation of the relevant load equipment plus an additional 10 per cent, for a period of 2 hours during mains failure, assuming a normal charge condition at the start of the mains failure.

The battery cases shall be made of polypropylene or similar translucent material such that the electrolyte level can be seen through the battery casing. All batteries shall be suitable for the intended service under the prevailing site conditions without excessive gassing or loss of electrolyte.

9.23.3 Battery chargers

Duplicate chargers one “duty” and one “Standby”, shall be provided and mounted on their own respective chassis in the upper cubicle compartment.

The controls for each charger shall be mounted on their own respective mounting plate and these, together with all controls and indicators projecting through the front of the upper compartment shall be positioned at a height not exceeding 1800 mm from floor level. The front panel of each charger unit shall include:

1 No. “ON/OFF” Mains Isolator
1 No. Lamp to indicate “AC Supply On” (White)
1 No. Charger Ammeter.
1 No. Lamp to indicate “Boost Charge” (Red)
1 No. Lamp to indicate “Float Charge” (White)
1 No. Lamp to indicate “Charger Failed” (Amber)
1 No. Lamp test pushbutton.

Each charger unit shall also be provided with:

1 No. “Float/Boost” selector switch mounted internally.
1 No. Set of AC supply fuses.
1 No. Volt–free contact for duty charger failed alarm.
1 No. Volt–free contact for low DC output voltage alarm.
1 No. Volt–free contact for loss of DC output voltage alarm.

The above volt–free contacts shall open under fault conditions and be wired to a terminal block.

The following items of common equipment shall also be provided and mounted on the front panel:

1 No. DC output voltmeter, scaled to indicate regions of “Low”, “Normal” and “High” output voltages, by the use of different coloured sectors.

1 No. DC output isolator Switch.
1 No. DC output Ammeter
1 No. Duty/Standby selector switch (labelled “No.1 Duty, No.2 Standby/No.2 Duty No. 1 Standby”).

The battery charger unit shall also be provided with one set of full capacity rated output DC terminals and fuses. In the event of failure of the duty selected charger, the standby charger shall be connected automatically and contacts for the remote alarm indication shall be provided. The alarm indicating failure of the duty charger unit shall remain on until the failed charger has been repaired and returned to operation.

Reversion from "Standby" to "Duty" charger shall be a manual operation. The chargers shall be of the solid state constant potential type, and shall be designed to regulate the charger output voltage to within ± 1 per cent for a mains input voltage variation of ± 6 per cent.

The DC terminal voltage shall be further regulated such that under "Float" or "Boost" charge condition the DC voltage does not rise to more than 10% above the nominal.

The charger unit shall also be provided with both short circuit and reverse polarity protection. The charger when selected to "Float" shall be capable of restoring the battery to 75% capacity within 7–8 hours.

Under "Boost" condition the charger shall be capable of restoring a fully discharged battery to 75% capacity within 4–5 hours. All internal and external components shall be labelled as specified above.

The cabinet shall be manufactured with additional treatment to the interior surfaces to pre-vent any corrosion by battery chemicals and with environmental protection to IP32.

For each battery/charger unit the Contractor shall supply a set of maintenance tools, equipment and spares, and for non–sealed batteries this shall include a resealable, 2 litre container of electrolyte, a pouring device and hydrometer; all of which shall be contained and secured within the charger cabinet.

The Contractor shall fix inside the cubicle a wiring diagram indicating and identifying all out-going terminals, components and fuses. Special precautions shall be taken in the sizing of the battery and charger for tropical use, and all equipment shall be adequately rated for the prevailing site conditions.

9.24 Plant control and indication circuits

The requirements detailed in this Clause refer specifically to control/indication circuits associated with power actuated valves and penstocks, but shall apply equally to all other plant controls/indications where similar conditions occur.

Although two or more auxiliary or limit switches may initially be set up to give simultaneous operation, it is impossible to ensure that such simultaneous operation will be maintained over an extended period. To avoid the possibility of a system malfunction due to the above, the use of duplicate auxiliary or limit switches to provide the same effective status signal will not be accepted.

Where a valve or penstock status signal is to be used in more than one circuit (e.g. control and indication), one set of auxiliary or limit switch contacts only, together with a slave relay if necessary, shall be used to initiate the operation of all such circuits.

9.24.1 Electromagnetic flow meters

Electromagnetic flow meters shall be in accordance with the following:

- •meters shall be of the short form, having a modulated, direct current excitation and inherent total zero stability,
- •the power consumption shall not exceed 16 W per 100 mm of diameter,
- •the output shall be 0/4-20 mA or 0 - 10 V and the system accuracy shall be within ± 1% of actual flow across the full range of the instrument,
- •a test certificate shall be provided for each instrument,
- •the field coils shall be fully encapsulated,
- •the equipment shall be guaranteed suitable for the ambient and process liquid temperatures,
- •each flow meter primary shall be supplied with a neoprene liner and electrodes of the material best suited to the particular process fluid,
- •primary units shall be suitable for accidental submergence to a depth of 3 m,
- •the Contractor shall provide primary units having flanges in accordance with the relevant specification relating to pipes, flanges, fittings, etc.,
- •the Contractor shall ensure that all primary units are rated to withstand the maximum possible fluid pressure, including possible surge pressures,
- •each primary unit shall be supplied and installed complete with a dismantling joint to permit removal for repair and inspection,
- •the flow meter equipment shall be supplied complete with amplifier (converter), drive unit (if applicable) and all cable for connecting between the components. The termination box shall be sealed to IP68 minimum,
- •the amplifier/converter shall be fully screened to prevent interference from adjacent equipment and shall be remote from the electrodes,
- •the amplifier/converter shall incorporate voltage stabilisation to ensure maintenance of system accuracy with a supply variation of ± 10%,
- •the Contractor shall provide a length of pipe having the same length and being flanged as the flow meter primary, to replace the meter should this have to be removed for repair,
- •the flow meter primary shall incorporate an electrode (or electrodes) to detect when the pipe is not full. The detector output shall control circuits within the converter to open circuit the analogue signal and initiate an indication of the "pipe not full" condition.

9.24.2 Ultrasonic in-line flow meter

Ultra-sonic flow measuring equipment for "in-pipe" applications shall operate on the phase difference technique employing 2 No. ultra-sonic probes displaced longitudinally and mounted on opposite sides of the pipe to detect the difference between the upstream and downstream flight times. The equipment shall include acoustic transducers and a transmitter, and shall be installed complete with all necessary fittings, cables and connectors.

The acoustic transducers shall be non-intrusive and arranged so that they may be removed without shutting down the process line. All materials in contact with the process liquid shall be approved for use in the specified application.

All items of equipment attached to the pipe and/or pipe insert shall be of non-corrosive material, designed to withstand continuous submergence to a pressure of 3 m head and guaranteed suitable for the temperature and process pressures, including maximum possible surge pressures.
The transmitter shall process the signals from the acoustic transducers and shall:

- •provide an output of 0/4-20 mA or 0 - 10 V proportional to flow,
- •be suitable for direct or wall mounting with up to 30 m of cable,
- •incorporate contacts to initiate an alarm in the event of mal-function,
- •incorporate temperature compensation,
- •include facilities for field checking and zero adjustment.

The complete system shall operate with a minimum accuracy of ± 1.5% of full scale deflection over the full ambient temperature range. A test certificate shall be provided for each set of equipment.

9.24.3 Orifice plate installations

Orifice plates shall be designed in accordance with ISO 5167 and supplied in carrier rings incorporating the pressure tappings. The sensing lines shall be installed with a continuous slope such that condensation will not collect in the pipe. Stop cocks shall be provided close to the tapping points.

9.24.4 Ultrasonic level measuring equipment

Where ultrasonic level measuring equipment is specified in the relevant application clause, level measurement shall be accomplished by the use of non–contact, echo–time measuring equipment operating at ultrasonic frequency. The equipment shall transmit pulses which are reflected back to the sensor from the surface of the liquid whose level is being measured. The equipment shall consist of a sensor incorporating both transmitter and receiver, together with a separate control unit.
The equipment shall be provided with automatic temperature compensation, shall be suitable for operation in the designated application under the specified climatic conditions. The sensor shall be suitable for mounting in the open, or within an enclosed tank, and shall be totally enclosed to IP68.

The control units shall incorporate facilities for adjusting independently both zero and span, and shall have an output of 0/4–20 mA or 0–10 V proportional to level.

The overall accuracy of the level measurements shall be within ± 1.0% of the instrument span.

The connection between the sensor and control unit shall be via commercially available screened cable, and the equipment shall operate with up to 150 metres of such cable. The Contractor shall ensure that each equipment is suitable for the application, particularly with regard to the blocking distance and transmitted beam angle or cone.

9.24.5 Installation of ultrasonic level equipment

Each ultra–sonic level sensor shall be installed on a robust and rigid structure provided for the purpose under this Contract. The structure shall include a means of levelling the sensor so that the transmitted beam is perpendicular to the liquid surface and shall provide a safe and easy access to the sensor for servicing and maintenance.

The Contractor shall provide, where applicable, a canopy above the sensor and/or the control unit to provide a protection from direct sunlight.

9.24.6 Differential pressure transmitter

Each differential pressure transmitter shall be of rugged construction, suitable for the application and:

- •have an electrical output of 0/4-20 mA or 0 - 10 V proportional to the differential pressure,
- •be capable of withstanding a 100% overload (i.e. twice the differential pressure required for full output) without sustaining damage,
- •have fully adequate static pressure rating to withstand all possible surge pressures,
- •have stainless steel sensing elements,
- •have independent span, zero and damping adjustments,
- •have an accuracy within ± 0.5% of span, repeatability within ± 0.2% of span and a dead band not exceeding 0.2% of the span,
- •be operable on a 2 wire system,
- •incorporate an output indicator.

Each installation shall be supplied and installed complete with:

- •sensing lines of stainless steel,
- •a 3 or 5 valve manifold as required,
- •test point(s) with separate isolating valve(s).

9.24.7 Pressure transducer level measuring equipment

Pressure transducer level measuring equipment shall comprise a strain gauge or differential transformer type pressure transducer, a controller/transmitter and be complete with all necessary cable, conduits, etc., as detailed below. Differential transformer transducers are to be preferred for very low ranges. Each pressure transducer shall be enclosed within an all welded, stainless steel case not less than 19.0 mm in diameter and shall:

- •have a single moulded cable which is securely bonded to the stainless steel case and comprising electrical connections, venting tube, strain cord or wire within the cable to obtain the necessary strength, and an outer covering suitable for the application,
- •be suitable for continuous immersion in all process fluids likely to be met in water applications including potable water, distillate, wastewater, raw sewage, primary sludge, secondary sludge, thickened sludge and final effluent,

- •be constructed so that the sensor diaphragm is protected against damage by shock, de-bris, etc., without restricting the transference of pressure changes from the surrounding medium,
- •incorporate automatic temperature compensation,
- •withstand a continuous overpressure of up to 400% without sustaining permanent deformation or calibration change. The controller/transmitter shall:
- •be suitable for mounting within a control panel,
- •accept the signal from the transducer and provide a 0/4-20 mA or 0 - 10 V output proportional to level (gauge pressure), for indication and control,
- •include independent zero and span adjustments,
- •have a system checking module which will simulate the transducer output.

The complete system shall provide an accuracy within ± 0.75% of span with a linearity better than ± 0.1%.

9.24.8 Pressure transducer installation

For installations in sumps and for similar applications where the depth is in excess of 3 m or where the available headroom over the sump is limited, the pressure transducer shall be in-stalled within a 100 mm dia. G.R.P. tube to provide protection against mechanical damage to both the transducer and the cable. The G.R.P. tubing shall have an adequate number of holes and/or slots to allow it to fill and drain as the level varies. The tubing shall be fixed to the sump wall at intervals not exceeding 2.5 m.

For installations where the sump depth does not exceed 3 m, the sensor shall be supplied and installed as a rigid assembly comprising a stainless steel tube, a tube holder (both as used for control electrodes) and the transducer, with the cable passing through the tube. The transducer shall be a close fit, located completely within the tube at the lower end. The assembly shall be fixed at not less than two places to the sump wall and installed with the bot-tom of the tube just clear of the sump invert.

For all installations the cable between the transducer and the controller/transmitter shall be a continuous length, and kept as short as is reasonably possible. This cable shall be run in conduit and installed well clear of all AC mains and power cables. All fixings, brackets, etc., as required for the complete installation shall be provided.

9.24.9 Electrode level control equipment

Electrode level control equipment shall consist of a control unit or units and a number of electrodes, together with all brackets and fixings as required for the complete installation. For all applications, sufficient electrodes and associated controls shall be provided to prevent "hunting" between the two states. The control unit shall:

- •have all live parts at a voltage in excess of 55 V to earth completely shrouded and fit-ted with warning labels,
- •have an output relay with double pole changeover contacts of suitable material for the application,
- •have a light emitting diode mounted on the front panel to indicate when the relay is energised,

- •have a lockable sensitivity control potentiometer,
- •be capable of operating at a distance of up to 100 m. from the electrodes.
- •have a voltage on the electrodes not exceeding 25 V.

The electrode and holder shall comply with the following:

- •the electrode holder shall be of the heavy duty type, fully weatherproof, constructed from die cast aluminium and provided with a mounting flange having a minimum of 4 No. fixing holes,
- •the electrode holder shall be designed to allow a minimum of 75 mm adjustment of the electrode length,
- •the electrodes shall be of stainless steel, having a minimum O.D. of 25 mm a wall thick-ness not less than 2.6 mm. The lower end of the electrode shall be sealed, and the upper end shall be locked to the insulator by a brass clamp,
- •cable entry shall be via a standard screwed gland entry,
- •each electrode shall be firmly secured to avoid any movement due to turbulences or flow velocity. The securing brackets shall be of the same material as the electrode and shall be installed above top water level,
- •where the electrodes pass through securing brackets; they shall be protected by heat shrunk sleeving extending from 300 mm above the bracket to 300 mm below the bracket.

9.24.10 Float switches

Float switches shall be the pendant type with the float suspended on a flexible cable, such that with the float free of the liquid the float and cable hang vertically, but with a rising liquid level the float shall rise and tend to invert.

The float shall be of robust design and comprise a mercury switch having changeover contacts encapsulated in a hard plastic foam and connected to a 3 core cable. The whole assembly shall be covered and hermetically sealed in Hypalon or similar material.

With the tilting action which occurs on rising level, the contacts shall change over, but there shall be a deadband between opening one contact and closing the other, during which period both contacts shall be open. This deadband shall operate over an arc approximately 20° either side of the horizontal.

The contacts shall be rated for a minimum of 5 A at 110 V. The voltage on the contacts shall not exceed 55 V (nominal) to earth. In all applications the installation shall be complete with approved means of preventing the float (and lead) from movement due to wind or liquid turbulence.

Where float switches are to be used in applications under which they may be submerged during normal operation (e.g. pump control and/or low level alarm); they shall be attached to a weighted chain to minimise movement due to turbulence and also to provide a means of raising the units for maintenance and repair. All brackets, fixings etc. as necessary for the complete installation shall be provided. The chain/float assembly shall be installed such that the point of suspension is not less than 400 mm from any side wall.

9.24.11 Flow switches

Flow switches for installation in pipe lines shall:

- •be suitable for the maximum possible flow rate,
- •withstand reverse flow without sustaining damage,
- •have the operating set point adjustable over the range 20% to 100% of the normal flow,
- •have change-over contacts rated at 5 A 110 VAC (50 Hz) or 1 A 24 V DC,
- •be complete with all fittings necessary to carry out installation in the pipeline, including waterproof cable gland,
- •have a metal housing compatible with the pipe material and rated for the system temperature and pressure,
- •be suitable for the application and process fluid in respect of the principle of operation and the material of the wetted parts.

9.24.12 Pressure switches

Pressure switches shall be of either the bellows or bourdon type, and shall be rated to withstand the maximum possible surge pressures. The switches shall:

- •have a signal pole change-over contact, with the contact material and rating suitable for the application,
- •have a calibrated setpoint adjustment which shall be lockable to prevent any movement due to vibration,
- •have a switching differential adjustable between 5% and 25% of the setpoint adjustment range,
- •have all wetted parts compatible with the process fluid,
- •be housed within an enclosure to IP55 or IP67 according to location.

9.24.13 Indicating meters and meter relays

All indicating meters and meter relays for use in control and instrumentation panels, control desks, mimics etc. shall comply with this Clause and the appropriate sub–clauses. All meters and meter relays:

- •shall comply with IEC 51 to accuracy Class 1 for instruments having a DC input and ac-curacy Class 1.5 for instruments having an AC input,
- •except those having digital, indication, shall have a linear scale, with clear graduations and markings,
- •shall have the units of the measured variable and any multiplying factor clearly marked on the scale plate or its equivalent,
- •shall be flush mounting with matt or semi–matt black bezel,
- •shall match all other instruments on the same panel or on similar panels in the same room as regards style, finish and appearance,
- •intended for installation within a control room shall be fitted with anti–glare or low reflectivity glass,

- •intended for installation on an inclined surface shall be suitable for that application, and when so mounted, the accuracy shall be maintained over the full range,
- •accept input signals of 0/4 – 20 mA or 0 - 10 V.
-

9.24.14 Digital indicators

The digital indicators shall have a 4 digit display with floating decimal point and shall:

- •display positive and negative readings,
- •display digits approximately 14 mm high,
- •have standard DIN format 96 x 48 mm,
- •accept a 0/4 20 mA or 0 - 10 V input and display in the relevant Engineering units,
- •have a sampling rate not less than 10 per second,
- •include a remotely initiated display hold facility,
- •be powered from the 24 V battery supply,

9.24.15 Meter relays

Meter relays shall comply with the requirements as detailed in the Particular Technical Requirements, but shall additionally incorporate one or two adjustable set point contacts for alarm or control.

The set point shall be visible and adjustable from the front and the signal output shall be via volt–free change–over contacts of suitable material and rating for the application.

9.24.16 Trip amplifiers

Trip amplifiers or analogue alarm relays may be single or dual set point instruments as required and shall:

- accept input signals of 0/4–20 mA or 0–10 V,
- have switched outputs with changeover contacts of suitable material and rating for the application,
- have a set point (or points) which is infinitely variable over the whole input range by means of a lockable knob calibrated 0–100%.
- have a dead band or hysteresis of not less than 3% of input span.

The units shall be located within the cubicle and mounted so that they are easily accessible for adjustment of set points. Trip amplifiers required to continue in operation during a period of power failure shall be supplied from the instrumentation system battery, either directly or via an inverter.

9.24.17 Integrators and counters

The integration equipment shall comprise an integrator and a 6-digit numerical display unit or counter. The integrator and counter may be combined into a single unit, or the integrator may be mounted remotely from the numerical display unit.

The counter shall be flush mounting with a matt or semi-matt bezel, and shall match all other instruments on the same panel as regards style, finish and appearance.

If a counter reset facility is provided, this shall be arranged such that accidental operation is impossible, and should preferably not be located on the front panel.

The integrator shall accept a 0/4-20 mA or 0 - 10 V signal proportional to flow. Integrators required to continue operating during a period of power failure shall be supplied from the instrumentation system battery, either directly or via an inverter. A low signal cut-off facility shall be provided on all integrators, and this shall be adjustable over the range 0.5% to 5% of the flow.

Integrated flows shall be in cubic metres and this, together with the measurement designation and any multiplying factor shall be clearly marked on the face of the counter, or on a matching label immediately below the counter. Unless otherwise stated in the application clause, the multiplying factors shall be as follows:

Flow Range Multiplying Factor

From	to	unit	multiplier
0	5,000	m3/day	x 1
5,001	50,000	m3/day	x 10
50,001	500,000	m3/day	x 100
Alternatively:			
0	60	l/s	x 1
61	600	l/s	x 10
601	6,000	l/s	x 100

The Contractor shall submit for approval by the Engineer details of integration rates and multiplying factors for all integrators to be supplied under the Contract.

9.24.18 Predetermining counters

Where a liquor sampler is to be function of flow and/or where indicated in the application clause, the relevant integrator shall incorporate a predetermining counter having a minimum of 3 digits. The predetermining counter shall be on the front of the instrument with thumb-wheel setting facilities and shall operate such that a relay with changeover contacts is enerised when the preset quantity is reached. The relay shall remain energised for approximately 1 second, following which the counter shall automatically reset and start counting again.

9.24.19 Control and interposing relays

All control and interposing relays, except those used for lamp switching, shall operate on a supply not exceeding 55 V (nominal) to earth and shall:

- operate reliably over the range +10% to 20% of the nominal supply voltage,
- be of the plug-in type complete with plastic cover and retaining clip,
- have vacuum impregnated coils and be suitably treated for operation under the specified environmental conditions,

- have contact material suitable for each application,
- have relay bases of the front connected, screw clamp type,
- incorporate indication of energisation

All relays operating on a DC supply shall have a surge suppression diode connected directly across the coil. Mixed voltages shall not be connected to the contacts of any relay. All relays and the associated wiring shall be protected by suitably rated fuses. Relays having different contact arrangements or coil voltages shall not be interchangeable. A permanent means of identification shall be fixed to each relay base and this identification shall be in accordance with the circuit diagram reference.

Where voltages from a remote source (i.e. voltages which cannot be readily isolated from within the cubicle), are connected to a relay or associated terminals, fuses etc., the Contractor shall ensure that all such live parts are fully shrouded and that appropriate warning notices are fitted.

The Contractor shall be responsible for ensuring that AC relays cannot be held in due to capacitance effects on long switching lines. Where such a possibility exists, a DC supply shall be provided.

9.24.20 Discrepancy switches

Where illuminated control switches are used to provide discrepancy indication, the circuits shall be arranged such that the lamp is energised via a flasher unit. This flashing discrepancy indication shall operate if the switch is not fully activated or if the controlled item is not in the position shown by the switch blade.

The switches shall be of the type having a rotary action to select the operation and a push button action to initiate the operation. All discrepancy switches shall be included within a lamp test facility.

9.24.21 Illuminated pushbuttons and status indicators

All lamp indicators (except discrepancy switches) located on instrumentation and control panels, mimics, desk or consoles shall:

- •be of similar size and appearance,
- •have bezel dimensions of not less than 24 x 36 mm,
- •incorporate two lamps,
- •be included within a lamp test facility,
- •be supplied complete with the required engraving on the screen,
- •be supplied from the local instrumentation power system or the local instrumentation system battery, unless stated to the contrary in the application Clauses.

9.24.22 DC operated lamps

All DC indicator lamps shall have diodes in series to prevent reverse current when making lamp tests.

9.24.23 AC operated lamps

In applications where a battery supply is not available, status indicator lamps shall be operated on available AC supplies. For these applications the indicator shall be a low voltage lamp supplied via a transformer incorporated within the light unit. The lamps shall have a voltage rating higher than the transformer secondary.

9.25 General testing, inspection and pre-commissioning requirements

9.25.1 Works testing and inspection costs

The Contractor shall offer all items of Plant for inspection examination and witness testing and shall give the Engineer four weeks' notice that the equipment is ready for operation and of his intention to carry out tests.

If the tests are beyond the resources of the manufacturer, he shall make arrangements for these to be carried out elsewhere. Any variation of this requirement shall be agreed and confirmation in writing obtained from the Engineer.

The Contractor shall carry out tests as stated in the current appropriate National or International Electrotechnical Commission Standards (EN, ISO or IEC), performance tests and such other tests as are necessary, in the opinion of the Engineer, to determine that the Works comply with the Specification, either under test conditions in the manufacturer's works, on site or elsewhere.

Where tests and inspection have been completed to the Engineer's satisfaction and when the test certificates, curves, etc. have been checked, the Engineer shall confirm acceptance in writing and the plant shall not be incorporated in the Works or delivered until this acceptance has been received.

Where witness tests are not required, the test certificate and performance curves shall be forwarded to the Engineer within two weeks after instructions to waive witness tests have been received. On each test certificate, sufficient information to enable the Engineer to is-sue a release certificate, including the Specification Contract number and details, shall be given for ready identification of the material or equipment to which the certificate refers. No inspection or passing by the Engineer of the Work, Plant or materials covered by the Con-tract, whether carried out or supplied by the Contractor, shall release the Contractor from any of his obligations under the Contract.

The Engineer reserves the right to require the Contractor to meet any extra costs which are occasioned by failure of the Contractor to comply with the above testing and inspection requirements and including the provision of test certificates, curves, sub orders, etc., or which in the opinion of the Engineer are due to insufficient care having been taken by the Con-tractor or his Sub Contractor before presenting the Plant for inspection or test. If unauthorised delivery has taken place, the Contractor may be required to arrange for the plant to be returned to the manufacturer for inspection and/or witness testing at the Contractor's expense.

Any equipment used in the testing of the Plant shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

The Contractor shall ensure that all sub-contractors are given copies of the Specifications. Full details of the method of testing proposed for each item shall be submitted to the Super-visor.

The Contract prices shall include for the costs of all works tests, including temporary erection, labour, materials, instrumentation, stores, fuel and power used, as may be required during all inspections and tests and for the provision of certified records and curves.

The Contract Prices shall also cover all the costs during works testing including accommodation, travelling expenses and all reasonable expenses, incurred by the Engineer, allowing for individual inspection visits each of a duration of two days. The above periods are deemed to exclude any necessary re-inspection visits arising from any abortive inspection visits, resulting from the Contractor's failure to comply with the requirements of this Section.

9.25.2 Test instruments

The manufacturer shall satisfy the Engineer as to the accuracy of all the instruments used for the tests and if required shall produce recent calibration tests, or otherwise have them calibrated at his own expense by an independent authority.

Kilowatt- and kilovar hour meters shall be checked for correct rotation and creep tests shall be carried out to ensure that the meter is inoperative with voltage alone if the secondary of the current transformers is left connected with the primary current interrupted.

9.25.3 Test certificates

Test certificates shall be provided giving a detailed record of all electrical and mechanical tests carried out on the equipment and material including lifting equipment, tanks, pressure vessels, cables and cabling both in the manufacturer's works and at Site. Copies of certificates of all works hydraulics tests shall be provided.

The Contractor shall obtain and submit to the Engineer and to other parties as may be directed, within two weeks of completion of any witnessed tests, test certificates and curves of all items certifying that they have been satisfactorily tested and describing and giving full particulars of such tests.

Copies of test certificates of major items shall be included in the Operating and Maintenance Instructions as detailed elsewhere.

9.25.4 Facilities hydraulic tests

All equipment subject to hydraulic tests including pressure vessels, pumps, pipes, fittings and valves, shall be hydraulically tested to the pressure where specified or to at least 1,5 times the maximum working pressure but not less than the pressure applicable to the PN rating.

Certificates of tests for all items shall be submit-ted.

Any of the hydraulically tested items shall be subject to the Engineer' random item proof re–test and notice of testing dates shall be submitted to the Engineer.

9.25.5 Facilities inspection, test and guarantees

Schedules of Particulars shall be prepared for the following items by the Bidder with Guaranteed Particulars and efficiencies of the equipment offered at the duties specified, and these will be binding and may not be varied except with the consent in writing of the Engineer.

Full witness testing to the relevant standards and to prove guarantees given will be required for the following items:

- •All Pumps with capacities of more than 15 l/s
- •All Blowers
- •All Control/Switch-gear Panels
- •All Circuit Breakers
- •All High Voltage Power Factor Correction Capacitors
- •All Process Control and Indicating Instruments
- •All Electrical Measuring Instruments and Meters
- •All Programmable Logical Controllers (PLC)

In addition, all other items of equipment not subject to witness testing shall be temporarily erected at the manufacturer's works, tested for satisfactory operation and offered for inspection. Certified copies of the manufacturer's test readings shall be submitted to the Engineer prior to packing for shipment.

Such inspection, examination, or testing, shall not release the Contractor, manufacturer or supplier of any item from any obligation.

Whilst the Engineer shall be provided with facilities for witness testing and/or inspection of all items of equipment at the manufacturer's works, he may at his discretion advise that the tests shall proceed in his absence, the tests shall be made as if in his presence, and duly certified copies of test readings shall be submitted.

Where items of equipment are of identical size and duty it may be required, at the Supervisor's discretion, that a reduced number of the items be subject to witness tests, however, this shall not relieve the manufacturers from the requirement of carrying out the performance tests on all items prior to offering for witness testing.

If after inspecting, examining, or testing any material or equipment, the Engineer shall decide that such items or any part thereof is defective, or not in accordance with the Specification or performance requirements, he may reject the said items or part thereof, giving to the manufacturer within a reasonable time, notice in writing of such rejection, stating therein the ground upon which the said decision is based. All retesting shall be at the manufacturer's expense.

As and when the Engineer is satisfied that the equipment shall have passed the required tests he shall notify the Contractor in writing to that effect.

9.25.6 Pumps

Each pump (more than 15 l/s) shall be witness tested as an integral unit for a capacity of 50 %, 100 % and 110 % of the rated capacities (duty points). The tests shall include efficiency curves

for the above capacities - both for the motors and for the pumps. Curves for motors may be based on the motor supplier’s efficiency ratings.

9.25.7 Blowers

Each lobe type blower shall be witness tested as an integral unit for a complete sequence of operation for capacities of 80 %, 100 % and just below the opening of the relief valve. The witness test shall obtain the guarantees of performance for each item of equipment.

Impellers of centrifugal air blowers shall be dynamically balanced and then overspeed tested to 15 percent above the maximum continuous service speed. The assembled blower units shall be proved mechanically by testing at contract service speed. Full tests shall conform to the appropriate requirements.

Tests shall be completed and witnessed at the manufacturer's works using a pipework system as required by the agreed code for aerodynamic testing. Blower testing shall be under-taken using the driver motor which will be coupled to the blower on site.

The manufacturer's test drive motor may be used subject to the Engineers written approval. Adequate reason for this option shall be supplied to the Engineer with the request to use other than the final drive motors to be used on site. Where variable volumetric output is required, the blower and motor shall be tested in combination with the control system which will ultimately be used for this purpose on site.

9.25.8 Low Voltage Devices

Low voltage circuit breakers shall be delivered with CE-marking in accordance with low voltage directives. Miniature circuit breakers shall be delivered with CE-marking in accordance with low voltage directives.

Low- and moulded voltage air-break switches and fuse combination units shall be delivered with CE-marking in accordance with low voltage directives. Low voltage contactors shall be delivered with CE-marking in accordance with low voltage directives.

All other electrical equipment shall be delivered with CE-marking in accordance with relevant directives.

All low voltage switching devices of current rating 100 A or greater shall be subjected to measurement and recording of circuit resistance. The test shall comprise measurement, at the main terminals of each pole with the contacts fully closed, of DC voltage and current (at 100 A or greater). The values of resistance for any two similar examples from a particular manufacturer's range shall not differ by more than 20%.

9.25.9 Transformers

If it is decided to supply transformers they shall be routine tested at the manufacturer's works in accordance with IEC 76. The Engineer will require to witness the following tests:

- Measurement of winding resistance.

- Ratio, polarity and phase relationship.
- Impedance voltage.
- Load losses.
- No–load losses and no–load current.
- Insulation resistance.
- Induced overvoltage withstand.
- Separate source voltage withstand.
- Further witness tests shall also be carried out in accordance with the following:
- Impulse voltages withstand. If the manufacturer can provide evidence covering impulse voltage withstand tests for transformers of similar type and design, Type Test certificates will be acceptable.
- Temperature rise. Where transformers of identical design and rating are being supplied, only one unit need be subjected to the full Temperature rise test and Type Test certificates supplied for the duplicate units.

9.25.10 H.V. power factor correction capacitors

Tests to include H.V. dielectric resistance, phase to earth - measurement of dielectric loss and loss angle capacitance and verification of kVAr.

9.25.11 Process control and indicating instruments

All flow, level and process measurement controllers, transmitters, recorders, indicators, vacuum and pressure gauges shall be subject to routine tests in accordance with EN 60269-4 and EN 837-1.

Test Certificates shall be provided against each item of equipment.

9.25.12 Electrical measuring instruments

Tests to ensure accurate operation of all meters, voltmeters and kilowatt- and kiloVar hour meters shall be undertaken in accordance with relevant EN/IEC standards.

9.25.13 Programmable Logical Controller (PLC)

The Contractor shall be responsible for testing all items of equipment comprised in the PLC system for correct operation.

9.25.14 Co–ordination of site testing programme

The Contractor shall be responsible for co–ordinating the programme of site testing of all items and to ensure that all parties concerned are present during any tests to obligate their responsibilities.

9.25.15 Cable tests during installation

During the period of site installation, the Engineer will carry out inspection of the works to ensure the standards of workmanship meet the Specification and are to his satisfaction. In the event of any part of the cabling installation failing to meet these requirements, the Con-tractor will be informed immediately and shall remedy the deficiency to the satisfaction of the Engineer. The Contractor shall:

•Inform the Engineer prior to the testing of the cables and shall be responsible for liaising with any other contractor to whose equipment the cables may be terminated to ensure that all parties concerned are aware of the impending tests, to guarantees the safety of personnel and that the isolation of any equipment has been completed. Any special isolation or preparation required to be carried out before cable testing can be completed, will be carried out by the Contractor responsible for that equipment. All tests shall be carried out by the Contractor but shall be supervised by the Engineer.

•Provide DC test equipment and apply (after isolation) in the presence of the Engineer, the following DC test voltages on all cables between cores, cores and sheath and cores and armour. Measure HV cables as follows:

XLPESWA PVC 20,000/35,000 V grade cable

between cores and between any core and screen/armour	76,000 V
XLPESWAPVC 5,800/10,000 V grade cable	
between cores and between any core and screen/armour	25,000 V/15,000 V

Measure LV cables 600/1000 V as follows:

PVC or XLPE 600/1,000 V grade cable	
between cores and between any core and armour	3,500 V

•Demonstrate correct phasing out of cores in all cables throughout the works and test the insulation of all the cables, both between the cores and between the cores and earth, during installation with a "Megger" 500 V hand generator.
•Conduct soil resistivity tests in the presence of the Engineer to obtain the most suitable location for the earth electrode system.
•Demonstrate to the Engineer that the resistance of the earth electrodes to earth conductor continuity and earth installation is in accordance with the specified requirements.

Tests shall be performed from each major item of plant, by using an "Earth Megger" and auxiliary return conductor. If any portion of the works fails to pass the tests, another test of the failed portion shall be repeated within a reasonable time upon the same terms and conditions.

Certificates of all testes carried out shall be provided giving full details and description of each test.

9.25.16 Tests on completion

After erection is completed and the equipment is running satisfactorily after primarily setting to work the Contractor shall notify the Engineer that he is ready to demonstrate the performance of the facilities. Such demonstration is referred to herein as Site Testing, which shall be witnessed by the Engineer. The Contractor shall then test fully all items of equipment and shall include provision and arrangement of:

- •All skilled and qualified operating and test staff for the testing of all equipment.

- •Provisions and disposal of all services, lubricants, and fuels and electricity.
- •All measuring and testing instruments to demonstrate equipment operates to the fulfilment of the works tests.

All tests shall be carried out by the Contractor under the supervision of and to the satisfaction of the Engineer, as follows:

9.25.16.1 Lifting equipment

Each installation inclusive of rails and beams shall be tested on site with test loads, provided by the Contractor, to prove that the whole is capable of satisfactorily lifting 25 per cent above its rated load (lift in centre of gantry where applicable) and certificates of site tests shall be provided.

9.25.16.2 Pumps

Each set tested for capacity, head power consumption and mechanical reliability.

9.25.16.3 Dosing equipment

Each set shall be tested for dosing the specified volumes. Efficiency of mixing shall be determined by taking samples and analysing for dissolved agent after 15 minutes, 30 minutes and one hour after start of mixing.

9.25.16.4 Electrical plant and power systems

For electrical plant and power systems the Tests of Completion shall comprise pre-commissioning tests as detailed below, prior to energisation from the power supply system, followed by energisation and demonstration of the operation of the plant and associated protection and control systems to the specified performance requirements and maximum operating and load duties.

On energisation a certificate of temporary acceptance will be issued for all Plant operating at 1000 V and above. Certificates of temporary acceptance will be issued for equipment on lower voltages on satisfactory demonstration of on-load operation.

All tests shall be carried out by the Contractor under the supervision of and to the approval of the Engineer, and shall comprise:

Switch-gear and Motor Control Centres:

Insulation testing.

- Power frequency pressure tests shall be carried out on all equipment for operation on systems above 1000 V.
- For systems up to 1000 V equipment insulation tests shall be carried out at 500 volt using an approved test instrument.
- These tests shall be carried out with all circuit breaker/contactor panels closed in the circuit position, between phases and phase to earth. All secondary small wiring circuits shall be similarly tested.
- Mechanical tests

- All mechanical tests specified for conducting on manufacturer's premises are to be re-checked to ensure satisfactory operation of the plant in the final erected state.
- Protection and control circuits
- The satisfactory operation of all current operated protection circuits over their whole operating range shall be tested by secondary current injection, where primary injection tests have been previously carried out on manufacturer's premises.
- Primary injection tests shall be carried out on restricted earth fault circuits, after pilot circuits have been completed, for stability and fault conditions. On transformer differential protection circuits where primary injection was not possible at the place of manufacture, the completed relay circuits are to be fully tested by secondary injection, and simulated fault conditions. Stability tests are to be carried out using normal load conditions after the system has been completed and energised.
- Instrument and metering equipment
- Tests shall be carried out to ensure the correct operation of current and voltage operated indication instruments when energised by the actual supply system.
- Continuity of earth conductors
- Continuity tests shall be carried out on the earth conductor within the switchboard, such tests being by current injection.

Power Transformers (if applicable)

- Samples of insulating oil shall be taken from each transformer at top and bottom levels and from every container and subjected to dielectric strength tests.
- Buchholz surge relays shall be tested after completion of pilot cables by stimulated oil level changes at the relay. Buchholz gas relays shall be tested with pilot cables connected by mechanical operation of contacts.
- On-load tap changer equipment shall be tested to ensure correct operation from associated control relays mounted on the switch-gear relay panels by voltage injection on the control relays.

Rotating machines (motors and generators)

- Before the application of electric power the machine windings, the insulation resistance shall be tested (with a suitable insulation resistance tester) and shall be greater than the manufacturer's minimum recommended figure when corrected for site winding temperature. Any necessary drying out the windings on site shall be in accordance with the manufacturer's recommendations.
- Before rotating any machine under power, the mechanical alignment of the shaft with the driven load (or driver) shall be checked (and adjusted if necessary) and shall be in accordance with the manufacturer's recommended figure.
- Before mechanically coupling any machine to the driven load, the direction of rotation shall be checked.
- Before running any machine on-load, all heavy current connections shall be checked for correctness of make-up and tightness.

9.25.17 Diesel generator sets

Tests shall be carried out in accordance with ISO 3046 under the control of the Contractor's staff and supervision of the Engineer. The purpose of the tests on completion shall be to confirm

the works tests and each engine and generator shall be tested to verify the particulars given in the Technical Schedule. Each set shall perform the guaranteed duty for a period of up to 4 hours or as the Engineer may determine.

9.25.17.1 Bulk fuel storage tanks

Prior to being put into service, each tank and associated equipment shall be subjected to a sustained pressure of 0.7 N/mm^2 to ensure that the installation is sound and shows no leaks or distortions.

9.25.17.2 Earthing systems

Test resistance of the earthing networks and electrodes for compliance with the National Electricity Company's Regulations.

9.25.17.3 Electrical equipment and installations

The Contractor will in addition be responsible for arranging and carrying out such witnessed or unwitnessed tests and inspections as may be required by the Electrical Supply Authority and obtain and hand over to the Engineer their certificate of approval of the complete electrical installation.

9.25.18 Building services

The Contractor shall demonstrate that the building services installations conform to the Specification and applicable local regulations. The tests shall include but not be limited to:

- For lighting installations;

Demonstrate that the illumination levels conform to the specified values.

9.26 "As-Built" drawings, maintenance and operating manuals

As each portion of the work is completed, the Contractor shall provide the Engineer with as-built drawings maintenance and operating manuals and other documents which are called for in the general electrical specifications, the project specification or any other specification or documentation forming part of this contract or as agreed upon.

The Contractor shall before the works are taken over by the EMPLOYER provide two complete sets of operating and maintenance manuals together with drawings and Technical data sheets of the works as completed in each station insufficient detail to enable the EMPLOYER to maintain, dismantle re-assemble and adjust all parts of works.

The installation will not be regarded as complete until all of the requirements of this section have been met.

9.27 Pre–commissioning and Guarantee period

Following the successful testing of all equipment, the Contractor shall be responsible for providing all skilled personnel for the pre-commissioning and contractual maintenance of the Facilities during the guarantee period as specified.

The installation shall be comprehensively commissioned as individual and integrated system as may be required by the configuration after the works are substantially complete.

The commissioning shall include interaction between other services and Contractors where interdependence are encountered.

A programme of the planned commissioning procedures shall be submitted to the Engineer at least seven days before commission commences to enable the Engineer to witness the commissioning.

9.28 Testing at Final Handing Over

The Contractor shall test, during and at the completion of installation, and if required, again at the expiration of the Guarantee period.

In the event of any test indicating failure to comply with the requirements, the fault shall be traced and cleared and the test shall be repeated after the fault has been rectified. The Contractor shall meet any subsequent cost. Wherever there is any equipment of an electrical nature supplied and installed in the system by others, the Contractor shall attend on and assist basis in balancing, adjusting, regulating, testing and commissioning of the said equipment/system e.g. air conditioning plant etc to the Approval of the Consulting Engineer.

9.28.1 Continuity and Insulation Resistance

Test shall be made to verify the continuity of every protective conductor; ring final circuit conductors and every conductor shall be tested separately to verify that the said conductor is sound and correctly connected. The test shall include all conductors and any extraneous conductive parts used for equipotential bonding.
Insulation resistance tests shall be carried out using a test voltage not exceeding 500 V, DC with all lamps removed, all current using equipment disconnected or if practicable, all local switches controlling such lamps/equipment open. All electronic devices shall be completely isolated so that they are not damage by test voltage.
Test shall be done in accordance with the chapter 71, 16th Edition of the IEE Wiring Regulations – BS7671: 1992 Insulation resistance of any two electrically separated conductors shall not be less than 20 megohms.

9.28.2 Earth Electrode Resistance and Earth Fault Loop Impedance

The earth electrode resistance and earth fault loop impedance shall be measured and the results shall comply with those of the National Electricity Company.

9.28.3 Polarity and Phase Rotation

Tests shall be carried out to verify that all fuses and single pole control devices have been connected in the phase conductor only and that the bayonet and Edson Screw lamp holders and

the socket outlets are correctly wired. Phase sequence tests shall be done to ensure that correct phase sequence is maintained throughout the installation.

9.28.4 Testing and Commissioning on Site

The Contractor shall provide at his own cost all-accurate and calibrated instruments and equipment and all labour required carrying out the above tests. The instruments and equipment shall be made available during final testing to enable the Consulting Engineer to witness such tests as he may require.

9.28.5 Factory Testing

The equipment included in this contract shall be tested at the Manufacturer's workshop (or elsewhere) by agreement for output and performance in accordance with the Manufacturer's recommendation or, if the equipment is not found sufficient, in accordance with the Supervisor's Specifications.

Tests sheets shall be submitted to the Engineer immediately upon the completion of the tests at the workshop.

9.28.6 Test Results

Extra result sheets as ap-pear in this document shall be completed. Test result sheets shall be submitted to the Consulting Engineer for Approval.

9.28.7 Completion Certificate

The Sub-Contractor, on completion of testing and commissioning of the installation/system shall submit to the Consulting Engineer all test results accompanied with the signed completion certificate as stipulated in Appendix 6 of 16th Edition of the IEE Wiring Regulations – BS7671: 1992 as reproduced in this document. The installation/system shall not be considered complete without this certificate. If the Sub-Contractor fails to issue these documents within a month from the date of practical completion, the Consulting Engineer may employ the services of others and deduct all costs from the Sub-Contractor's account.

10. INSPECTION AND TESTING OF WORKS AND EQUIPMENT

10.1 Testing of Earthworks

10.1.1 General

The Contractor shall furnish all equipment and materials necessary for collecting samples and carry out field laboratory tests on materials for earthworks. Laboratory equipment shall be housed in a suitable building on site, which shall also incorporate space for the storage of field test equipment.

10.1.2 Main Tests and Standards

The Contractor shall carry out all tests in accordance with ZTVE-STB 94 or equivalent ASHTO or BS standards. For the various tests the following DIN standards shall apply:

DIN18121	Moisture Test	DIN18125	Density Test for Soils (including voids)
DIN18122	Consistency Test	DIN18127	Proctor Test
DIN18123	Grading Tests	DIN18134	Loading Test
DIN18124	Density Test (solid volume without voids)		

10.1.3 Compaction of Soils

The Contractor shall carry out the compaction to safely achieve the specified dry density and control soil compaction during backfilling and filling operation.

Where the sub grade or layers of soil material require being moisture conditioned before compaction, the Contractor shall uniformly apply water to the sub grade or layer of soil to attain the optimum moisture content required. The application of water shall be carried out in a manner to prevent free water appearing on surface during compaction operations.

The Contractor shall replace soil material that is too wet for compaction to the specified densities.

10.1.4 Testing of Compaction

The Contractor shall inspect, perform and report all testing and retesting as to ensure that the works conform to the specified requirements. In order to test the degree of compaction, the Contractor shall carry out field density tests in accordance to DIN18127 or B.S. 1377.

For each compacted backfill of trench the required number of field density tests to ensure compliance with specification shall not be less than three passing tests between each 2 manholes or 100 linear meters (whichever is smaller) of filled and compacted trench.

If, in the opinion of the Engineer, the sub grade, backfill and fill layers have been placed and compacted to densities below the specified limits, the Contractor shall provide additional compaction

and testing until satisfactory results are attained or remove certain sections of the work and reconstruct them according to the Specifications at his own expense.

All holes made for the purpose of tests shall be restored by the Contractor to conform to the characteristics of the adjacent layers. This work shall be conducted at the Contractor's expense.

The compaction required for various fills shall be as follows:

Item of Works	Materials Prescribed	% of Max. Density
Backfill for over-excavation	Granular material	100 %
Formation and bedding layers	Fine granular material	95 %
Crushed stone supporting layers	Crusher runs	95 %
Final backfill of trenches under roads	Fine granular material	100 %
Backfill of trenches in general	Fine granular material	98 %
	Sandy material	95 %
	Clayey material	93 %
Backfill below structures	Fine granular material	100 %

10.2 Inspections and Testing of Civil Works

10.2.1 Inspection Prior to Commencement of Works

Buildings and other structures in close proximity to the construction Site that might be damaged by excavation or other work shall be inspected before work is commenced.

All parties concerned shall be invited by the Contractor to participate in the inspection.

The Engineer and the Contractor shall make the inspection jointly and the Contractor shall, at his own expense, set out an inspection report, including "preconstruction photos" as described in Chapter 2.3.7.

The report shall describe the conditions of the buildings, roads, footpaths etc. in question.

Any failure or damage caused by excavation or other works, shall be repaired and maintained by the Contractor at his own expense without any delay.

10.2.2 Testing of Concrete Works

10.2.2.1 Concrete Works, Test Certificates

Unless otherwise directed by the Engineer, the Contractor shall supply and submit to the Engineer:

Manufacturers test sheets with each consignment of cement and admixtures certifying the compliance with the relevant standards.
Certification of the calibration of weighing and dispensing equipment on the batch mixing plant.

The certified test results for all tests carried out on aggregates, water fresh and hardened concrete.

In case of doubts, new tests shall be executed upon the Engineer's direction at the Contractor's expense.

10.2.2.2 Concrete Works, Inspections

No concrete shall be placed until the Engineer has inspected and approved the surfaces upon which the concrete is placed the formwork and the reinforcing steel.

If requested by the Engineer to do so, the Contractor shall institute a "pour card "system in which a card is made out for each lift of concrete and is initialled by the Contractor and the Engineer confirming that the inspections have been carried out.

The "pour card "shall include spaces to identify the concrete being placed and to signify the completion of the inspections by the Contractor and the Engineer in regard to:

- Preparation of surfaces on which concrete is to be placed;
- Formwork;
- Reinforcement;
- Readiness for concrete placing;
- Striking time of formwork
- Inspection after removal of framework (remedial work directed);
- Curing procedures
- Completion of remedial work (if any)

10.2.2.3 Sampling and Testing of Aggregates

The Contractor shall sample and carry out mechanical analysis of the fine aggregates and each normal size of coarse aggregate in use, employing the method described in DIN4226 at least once a week when concreting is in progress and at such more frequent intervals as the Engineer may require.

The grading of all aggregates shall be within specified limits. Should the fraction of aggregate retained on any sieve differ from the corresponding fraction of aggregate in the approved mix by more than 5% of the total quantity of fine and coarse aggregate, the Engineer may instruct the Contractor to alter the relative portions of the aggregates in the mix to allow for such differences.

10.2.2.4 Sampling and Testing of Concrete

The Contractor shall provide the equipment necessary to determine the compacting factor of freshly mixed concrete at each place where concrete is being prepared and shall determine the compacting factor of the freshly mixed concrete by the method described in DIN1048 on each location where a set of test cubes is made and not less than once a day or as the Engineer may direct.

Unless particularly specified, for each grade of concrete works test cubes shall be made whenever required by the Engineer but not less frequently than one set of cubes per 25 m^3 or part thereof concreted per day.

Each set of cubes (six cubes per set) shall be made from a single sample of a concrete batch taken by random. Each three cubes shall be tested 7 and 28 days after manufacture.

When requested by the Engineer, additional set of cubes shall be made for testing 3 days after manufacture. Test reports shall be submitted to the Engineer in duplicate.

10.2.2.5 Compliance with Specified Requirements

The concrete shall be deemed satisfactory provided that:

The average 28 days strength fcm determined from every group of four consecutive test cubes must be fck + 8 N/mm² and the minimum strength of each cube must be fck, i.e. for grade C 20 / 25 concrete the average value must be 28 N/mm² and the strength of each cube must be 20 N/mm² minimum.

Each individual test result shall be greater than 85% of the specified characteristic strength.

If one cube result fails to meet the second requirement, the result may be considered to represent only the particular batch of concrete from which the cube was taken, provided that the average strength of the group satisfies the first requirement.

If more than one cube in a group fails to meet the second requirement or if the average strength of any group of four consecutive test cubes fails to meet the first requirement, then all the concrete in all the batches represented by such cubes shall be deemed not to comply with strength requirements.

10.2.2.6 Non-Compliance with Specified Requirements

When the average strength of four consecutive test cubes fails to meet the first requirement, no further concrete from that mix shall be placed in the work and the Contractor shall establish the cause of the failure and apply such remedies as are necessary.

The Contractor shall demonstrate by trial mixes and test cube results that the revised mix is in accordance with the specified requirements.

The Contractor shall, within 24 hours of the date of testing, make proposals for agreement with the Engineer about actions to be taken in respect of any concrete represented by the test cubes which fail to meet either of the requirements. These proposals may include, but shall not be limited to, cutting and testing cores.

Concrete, which is ultimately not found to comply with any of the requirements of the Specification, shall be broken out and replaced or otherwise dealt with as agreed by the Engineer at the expense of the Contractor.

Furthermore, the Engineer may order additional cement to be added to the mix immediately. The mixes used may also be changed whenever, in the opinion of the Engineer, such change is necessary or desirable to secure the required workability, density, tightness, surface finish and strength, and the Contractor shall not be entitled to additional compensation because of such changes.

10.2.2.7 Cutting and Testing of Core Samples

As and where directed by the Engineer, cylindrical core samples shall be taken normal to the surface of the hardened concrete for examination and testing.

The procedure for drilling, examination, measurement and testing shall be in accordance with DIN1048.

Prior to the preparation for testing, the specimen shall be made available for examination by the Engineer.

If the crushing strength of the specimen determined in accordance to DIN1048 is less than the characteristic strength at 28 days for the grade requirements in other aspects, that concrete in that part of the works of which it is a sample shall be considered not to comply with the specified requirements.

10.3 Inspection and Testing of Pipes and Mains

10.3.1 Testing at Place of Manufacture

The manufacturer shall, at the place of manufacture, test all type of pipes, fittings and pipeline appurtenances listed in the Bill of Quantities, including all necessary jointing material and mark them. The Contractor shall submit the certificates prescribed by the respective Standard Specifications.

The Engineer may witness such tests without incurring any responsibility for the materials.

10.3.2 Tests of field welds

All field welds at main diameters exceeding DN 300 or PN10 shall be subject to an ultrasonic test.

10.3.3 Pressure Testing of Mains

The Contractor shall submit a systematic procedure for testing and method of filling and draining all mains and pipework for approval to the Engineer. The pressure drop method shall be applicable as set forth by EN805 Chapter 11.

Test pressure of the mains shall be 1.5 times the operating pressure of the mains but not less than stated in the following table. The test pressure always applies to the lowest point of a test section.

System test pressure STP		
Kind of main	**Class = PN**	**System Test pressure STP**
Local main	PN6, PVC-U	11bar = 6 bar + 5 bar
Principal main	PN10, ductile iron	15bar = 10bar + 5bar
Trunk main	PN16 ductile iron	21bar = 16bar + 5 bar
	PN25 ductile iron	30 bar = 25bar + 5 bar

The Contractor shall perform the hydrostatic test, on all complete piping, prior to field coating of welds and fittings and prior to backfilling of the joints.

The Contractor shall provide and fit any test heads required, and the Engineer shall be informed in time to make a final check of each section to be tested before test heads are connected. The Contractor shall ensure that any necessary bosses on the test heads or pipework are included as required for filling and venting during site testing. Fill and vent points in the pipe shall be closed afterwards. Thrust blocks shall be provided and removed after testing. Tests shall not be performed against valves but against blank flanges and test heads exclusively.
.
Calibrated manometers of class 0,6 ∅ 160mm shall be used for testing and be placed at the lower end of the test section.

Water filling may start after opening valves or hydrants from existing system if approved by the Engineer or from tanker trucks. Before start of test, air must be completely removed from the test section as its presence falsifies the test results.

If visible leaks have to be contemplated in the test section, the test has failed irrespective of the recorded pressure drop. Pressure drop shall not exceed 20kPa = 0,2bar during 2 hours of main test, otherwise the test has failed

10.3.4 Testing of Water Meters for House Connections

Water meters for house connections shall be tested and calibrated at the factory in accordance with test certificates shall be issued and submitted to the Engineer for approval. The meters shall bear the seal of the calibration bank. The certificate shall include precise information on the test and calibration processes applied.

Tests shall be conducted with 10 meters out of 1000 but not less than 5 per each size. Test pressure shall be 16 bar during 15 minutes. Meters shall show no of leakages of body and seals. The hydraulic parameters shall be determined and compared to the requirements of the standard. If two or more meters do not pass the tests, the batch shall be rejected.

10.3.5 Pressure test for headers, manifolds and other pipework in plant.

The prescriptions of 10.2.1shall apply accordingly.

10.3.6 Tightness test of water tanks and reservoirs

Tightness test shall be carried out before any backfill around the tank subject to test takes place. All outside surfaces of the tank walls must be cleaned, smoothened and be completely visible and accessible. Each tank of a multi-tank reservoir shall be subject to a separate test.

Filling of a tank shall take place during daylight to allow for continuous inspection during filling. Tanks shall be filled up to high water level as indicated on the drawings or as otherwise instructed by the Engineer.

For tanks completely or partially made of concrete, the Contractor shall maintain a tank subject to test full over a period of 7 consecutive days prior to the test to achieve saturation of the concrete exposed to water.

For tanks completely made of steel such saturation period is not required, and the Contractor shall maintain the tank full one day prior to start of test.

A visual check of all concrete wall surfaces shall then take place. If such inspection does not identify visible leakages or wet spots, the test can continue. If such inspection however identifies leakages and wet spots, the test will be terminated and the Contractor shall proceed with repairs of the respective parts as instructed by the Engineer. Thereafter the procedure shall be repeated. Reference: DVGW W311 12 (1988).

After having successfully passed the visual inspection of the external surfaces, the main test shall be undertaken. The main test shall last 48 hours. During that period of 48 consecutive hours all ventilation hoods and accesses shall be tightly closed and sealed. Water level shall be measured at the beginning and end of the main test period. If water level drop does not exceed one (1,0) cm or 3/1000 of storage height, whichever is less, the test is passed successfully.

Water for the successful tightness test shall be supplied free of charge by the Employer through the connected mains. The Contractor shall pay to the Employer the water for any unsuccessful test at the rate for industrial bulk users.

10.3.7 Monitoring of settlements

From start of filing until completion of the test, the Contractor shall monitor the settlements of the tanks through precision levelling on the benchmarks grouted into the concrete as directed by the Engineer, particularly at the four corners of rectangular tanks and every 90° at the circumference of round tanks.

Frequency of levelling and recording formats shall be as instructed by the Engineer.

10.4 Tests at Completion

Tests at Completion shall be carried per each hydraulic system separately upon request of the Contractor. The Contractor shall prepare for each system a detailed program for the test runs. These tests shall be carried out under the direction of the Engineer and shall demonstrate that all mechanical, electrical control systems work satisfactorily an integral functional system.

The program shall be elaborated in such way as to provide tests for each individual element but also for the entire system as a whole. The program shall provide for simulation of normal as well of all extreme operating conditions, in particular to simulate the performance of limit switches or alarms at low and high-water level. Surges shall be simulated by sudden shutting off of pumps. The Contractor shall provide measuring equipment to monitor peak pressures during surges.

For complete transmission systems the tests at completion shall serve to determine the actual capacities of the various elements through the full rangs of possible operations.

In case that at the time of tests at completion requested by the Contractor connections to the public power supply have not been completed by the Power Corp., the tests shall be carried out with power generated from the stand-by generating sets.

For mains the pressure test shall be deemed to constitute part one of the test at completion, subject to a successful test at normal operating pressures which shall constitute part two of the test at completion of mains. During this second part, the satisfactory function of valves, in particular air valves, washouts, hydrants, shall be tested.

11. PROJECT ENGINEER'S REQUIREMENTS

11.1 Facilities for Engineer

The procedure to be followed in providing the Engineer's facilities (requirements) such as vehicles, office accommodation, equipment and furniture for the office shall be as outlined below:

The Contractor shall first submit the technical details, together with any brochures and leaflets, of the vehicles, equipment, furniture, etc for approval by the Engineer.

The Engineer shall inspect the proposed facilities, where appropriate, at the supplier's premises.

The Engineer shall approve or make comments on the proposed facilities. The Contractor proceeds to procure the approved facilities.

The Contractor shall be responsible and shall be deemed to have allowed in his rates and prices, for delivery of facilities to their final destinations, unpacking, disposing to rooms, assembling, connecting up and testing of electrical appliances, installation of all the required software, and setting the facilities to work.

11.1.1 Office for the Engineers Staff:

The Contractor shall provide a Site office, for the use of the Engineer. The Contractor shall maintain, service and insure the offices for the Contract period or for such additional or lesser time as the Engineer may direct. The offices shall be for the sole use of the Engineer's staff.

On completion of the Works, or at such time as specified by the Engineer, the ownership of the office (if not rented) and all furniture and equipment, except for survey equipment, shall be transferred to the Employer. Prior to handing over to the Employer, the Contractor shall provide and maintain the office accommodation, furniture, equipment, facilities and services without any interruption.

The Contractor shall carry out complete redecoration, including re-painting, of the office accommodation before handing over to the Employer. The Contractor shall be deemed to have allowed in his rates and prices for this redecoration.

Location of the Buildings
The Site office building shall be provided at a position on the Site or as specified by the Engineer.

Surface water drainage facilities shall be provided to protect the buildings from surface run-off and to convey it away from the buildings.

Site Office Building
The Contractor shall construct or alternatively rent a Site Office Building.

The Site Office Building shall have a minimum floor area of 125m^2 and a clear inside height of not less than 2.6 m to accommodate 7No. Staff. The Contractor shall submit his proposals for the Office Building to the Engineer for approval. The offices shall be constructed of new, durable, strong and weatherproof material to the satisfaction of the Engineer in respect of design, siting and construction. The floor shall be of suitable construction adequately damp-proofed, ant-proofed and termite-proofed.

The whole of the office accommodation shall be adequately ventilated, insulated against heat and cold, water tight, lighted, painted, mosquito proofed and vermin proofed. It shall be adequately wired for electric light and power. The building shall have burglar proof lockable doors, burglar proof windows with lined curtains and shall be divided up by block work partitions into private offices and meeting rooms as required by the Engineer. Covered communal passageways shall connect separated units.

The Engineer's office shall have a toilet, in addition to a set of communal toilets, to cater for the Engineer's staff. Each toilet shall be complete including wash hand basin, towel rail and toilet roll holder. The office shall be provided with a kitchen complete including kitchen sink and tile-topped working surface.

The office accommodation shall be detached completely from the Contractor's site offices although they may both be contained within one compound suitably guarded and fenced with a 1.8 m high chain-linked fence and gate with padlock and chain.

The Contractor shall provide 24-hour armed security guarding for the Engineer's office.

The Contractor shall provide all services and infrastructure. The Contractor shall provide a piped potable water supply to the toilets and kitchens with a waterborne sewerage system discharging to septic tanks, cesspits, or soak away pits, a storm water drainage system, and a yard tap with a lockable device. The Contractor shall provide an electricity supply of sufficient power for general use. The Contractor shall be responsible for maintaining the water and electricity services and pay all charges and fees for the supplies.

The Contractor shall provide and maintain cleaning staff and cleaning facilities. The Contractor shall also provide an adequate refuse disposal service for the office. The office, including toilets, shall be cleaned daily and shall be maintained for the duration of the Contract. A supply of toilet paper, soap and towels is to be provided and maintained; clean towels are to be supplied each day.

The office as well as all the equipment and furniture supplied under this Contract shall be insured on a full comprehensive basis against theft, fire, water damage and burglary.

The office with all furniture, fixings, equipment, services, carport etc., all as detailed below, shall be provided complete within 60 days after the Commencement Date. Until the office accommodation is ready for occupation, the Contractor shall provide, starting from the Commencement Date, alternative office accommodation of comparable area and facilities to the satisfaction of the Engineer. This alternative office accommodation shall be furnished and equipped with similar facilities as described below. If the office accommodation for the Engineer's staff is not ready for occupation within the specified period of 63 days, the Contractor shall provide, at his risk and cost beyond the specified period of 63 days, the alternative office accommodation for the Engineer's staff.

Roads and Parking

All accommodation shall be provided with temporary, well drained access roads 3m wide and covered carports for 3 cars. Access roads and the surfaces of the carports shall be surfaced with a minimum thickness of 150 mm of well- compacted gravel properly graded, cambered, drained, and culverted. The carports shall be surfaced with a minimum thickness of 50 mm of well- compacted crushed stone aggregates of 20 mm nominal size.

In addition, the access and other roads around the offices shall be treated to make them dust free by using crushed stone. They shall be well-drained and kept trafficable and free from mud at all times.

Furniture, Fixings and Equipment

The Contractor shall supply the furniture, fixtures and equipment listed in the table below, and shall install them in the offices as required by the Engineer. They shall be for the sole use of the Engineer and his staff. All furniture, fixtures and equipment shall be supplied new, following the Engineer's approval of a manufacturer's description or catalogue. The Contractor shall keep insured all furniture, fixtures and equipment to their full value (including duty where appropriate) and shall maintain them in good order until the end of the maintenance period. On completion of the Works, the equipment shall be transferred to the Employer.

Stationery and Office Supplies

The Contractor shall supply all stationery and office consumables required for the normal functioning of the Engineer's offices, including inter alia survey books, drawing office supplies, computer CDs (re-writable and recordable), computer printout paper, (but excluding headed correspondence paper), copying paper, cartridges for printers, box files A4, index dividers for A4 box files, ruled pads A4, squared pads A4, pocket files (document wallets) A4, erasers, self-sticking notes (post-it), pens (assorted colours), envelopes (assorted sizes), pencil refills (leads) 0.5 mm 2B or HB and staples.

The Contractor shall also supply books for Site records including: Daily Works Records, Notice of Operation, Request for Inspection/Approval, Measurement Records (Sheets), Confirmation of Verbal Instructions, Site Instructions and Site Diary. The books shall be of A4 size, with minimum of 50 pages; and each page shall be self-carbonized and in triplicate; and each page shall have a serial number. A sample page of each book shall be approved by the Engineer before the Contractor places procurement orders for the books.

The Contractor shall supply all the required stationery, office consumables, spare parts for office equipment, and books for Site records from the Commencement Date until the Taking-Over Certificate has been issued for the Works or until such time as specified by the Engineer. If the Contractor fails to provide the supply, the Engineer shall be entitled to withhold the issue of a Payment Certificate until such time as the supply is provided.

Gas and Electricity

The Contractor shall supply or make provision for 24-hour water, gas and electricity supplies to the Engineer's Site office and shall arrange for sewage and refuse disposal.

Whenever these supplies are not available from the public utility services, the Contractor must continue to provide the facilities from his own resources.

Communications
The Contractor shall provide for internet data and airtime for the Engineer's office and staff.

The Contractor shall allow in his rates for paying all costs, charges and fees in connection with the provision of the above facilities.

Furniture, Fixtures and Equipment for the Engineer's Office

Item Nr	Description	Unit	Quantity
	Supply, install, connect and set to work the following items of furniture, fixtures and equipment for the Engineer's office.		
1	Desk, metal framed (2.0 m x 1.0 m approx.), with 6 drawers fitted with locks	nr	2
2	Chair, swivel, upholstered, wheeled chair with arms for above desks	nr	2
3	Desk, metal framed (1.7 m x 0.8 m approx.), with three drawers fitted with locks	nr	2
4	Table, metal framed (1.2 m x 0.9 m approx.)	nr	2
5	Chair with arms for above desks	nr	3
6	Table, metal framed (4 m x 2 m approx.)	nr	1
7	Chairs, metal framed, upholstered for above table	nr	6
8	Filing cabinet, metal, 4 drawers with suspended filing system with a lock	nr	1
9	Cupboard, double door, metal with 4 shelves, locking (0.9 m wide x 0.45 m deep x 1.8 m high approx.)	nr	1
10	Waste paper basket	nr	3
11	Letter tray, A4 size (each set of 3 trays)	set	3
12	Sundry office items: paper punches (4 inch 1 heavy duty), staplers (4 inch 1 heavy duty), scissors (4), staple removers (4), clutch or mechanical pencils 0.5mm (4) clipboard A4 size (4),	set	1
13	Benching and shelving as required		Nil
14	Laptop computers as specified	nr	1
15	A4 colour printer HP Office jet 7000 Wide Format capable of printing up to 33 pages per minute (ppm) Pro MFP	nr	1
16	Internet facilities	nr	1
17	Gas plate	nr	1
18	Electric refrigerator 0.28 cubic metre capacity	nr	1
19	Electric Philips metallic kettle, minimum capacity of 1.7 litres	nr	1
20	Drinking mugs	nr	12
21	Crockery set comprising: 1 thermal flask (1.5liters), 1 tea pot, 1 milk jug, 3 sugar bowls, 12 cups and saucers, 12 side plates, 18 tea spoons, 12 small knives and 2 metallic flasks each of capacity 2 litres	set	1

Item Nr	Description	Unit	Quantity
22	Tea tray	nr	3
23	Electric fans	nr	3
24	First aid kit	nr	1
25	Notice board, secured (1.5 m x 1 m approx.)	nr	1
26	Toilet brush with holder	nr	2
27	Mop and bucket	nr	2
28	Plastic bucket	nr	3
29	Plastic jerry cans 25 litre capacity for water	nr	3
30	Broom	nr	2
31	Dust pan and brush	nr	2

Computers
The Contractor shall supply computer hardware and software as detailed below for the sole use of the Engineer and his staff.

Laptop Computers
The Contractor shall supply 2 (Two) laptop computers with specifications as follows:

High Performance Laptop Computer Specifications

Item	Minimum Configuration / Specification
Preferred Make/Brand	Dell, HP, or Better Brands
Processor make and speed	11th Gen, Intel core i8 processor CPU T7200, 2.8 GHz upto 3.9 GHz
Cache	1MB on-die L2 cache
Memory (RAM)	8 GB, DDR SDRAM
Hard disk	500 GB, at 7200RPM
Display	14-inch SXGA + TFT LCD
Networking (integrated)	Integrated 10/100/1000 MBps Ethernet Network adaptor Integrated Wireless network card (802.11b), Wi-Fi
Graphics Card	Intel HD Graphics 620 or better
Modem	Integrated 56k, v.92 modem
Audio facilities	Integrated audio (soundcard & speakers), with jacks for Headphone & microphone
PC Card slots	PCMCIA slot for either Type I or II
Ports	Parallel Port, 25hole, bi-directional or ECP Integrated Infra-red port (IrDA 1.1), 3 USB 2.0 ports, Video, 15-hole, SD card reader, Blue tooth enabled, Com port
Power	Integrated Lithium Ion battery, with 3-pin UK or Mobile plug AC adaptor
Security feature	Embedded finger print reader, Security lock slot with the cable locks and keys to be included with the laptop

Item	Minimum Configuration / Specification
Camera	In-built web Camera
Operating System	Windows 11 Professional – 64 Bit
Application Software	- Microsoft Office Professional 2019 or Higher – Preinstalled and licensed
	- Microsoft Project Professional 2019 or Higher – Preinstalled and licensed - Autodesk AutoCAD Civil3D 2022 Licensed - Latest, Upgraded Kaspersky Antivirus
Accessories	- USB Mouse – with Wire - Laptop Backpacker – approved by the client

Note: All Software should be supplied with their respective Original Installation DVDs

The computers shall be true branded Dell or similar approved and shall be approved by the Engineer. All hardware and all software shall be supplied new and fully licensed in the name of the Employer.

Printer and Related Equipment
The Contractor shall supply one office jet A4 colour printer as specified below:

- Colour Printer: HP Office jet 7000 Wide Format or similar approved capable of printing up to 33 pages per minute (ppm) black and 32 ppm colour.

On completion of the Contract or at such time as specified by the Engineer, the ownership of all computers and such like equipment shall be transferred to the Employer. The laptop computer will be handed over to the Employer at the end of the Defects Notification Period.

11.1.2 Services to the Engineer:

The Contractor shall supply such labour, either continuously or from time to time, as may be required by the Engineer, to assist in the checking of materials on Site and in the laboratory, the setting out of the Works and in measuring the Works.

The Contractor shall provide all tools, protective clothing, wooden pegs, iron pins, water, concrete and transport for labourers as may be required by the Engineer and his staff for supervision of the Works.

The Contractor shall keep all buildings provided by himself or the Employer, for the use of the Engineer and his staff, in a well maintained, clean and fully habitable condition and shall maintain all access roads, car parks, footpaths, fences, gates, drains, potable water supplies and water-borne sewage disposal systems in a good state of repair, all to the satisfaction of the Engineer. The Contractor shall also provide an adequate refuse disposal service for all residences and offices.

The Contractor shall maintain all furniture and equipment, provided by him, in a good state of repair and usable condition and shall replace any item which becomes unserviceable due to fair wear and tear.

The Contractor shall provide soap and towels in the offices of the Engineer, cleaning and sanitary staff and cleaning equipment.

Contractor shall provide day and night watchmen for the security of the Engineer's site offices.

11.1.3 Laboratory: - NOT USED

Test equipment shall be provided and housed and maintained by the Contractor to carry out the following on site; this equipment shall remain the property of the Contractor:

(j) Apparatus conforming to BS 1881 "Methods of Testing Concrete" to enable site compaction and slump tests to be performed and sufficient steel cube moulds, with base plate and tamping rods, to enable the sufficient test cubes to be made to meet the requirements specified in clause 2.2.5.

(ii) One complete set of BS sieves to comply with BS 410 for "Test Sieves" and all other apparatus necessary for testing grain sizes of gravel, sand and coarse aggregate

(iii) Complete set of apparatus to compaction tests (Sand Cone Replacement Method) in accordance with BS 1377.

In case the Contractor fails to provide the above apparatus, he shall make arrangements with a competent laboratory to the approval of the Engineer to carryout the respective tests.

11.1.4 Survey Equipment:

The Contractor shall avail as and when required, maintain and service the survey equipment required by the Engineer for as long as the Engineer shall require. The equipment shall be provided for the sole use of the Engineer and his staff. At the end of the Contract the equipment shall be returned to the Contractor

The Contractor shall make available any poles, pegs, staging, moulds, templates or profiles required by the Engineer for checking or for measurement of the Work including maintaining in position any poles, pegs, templates or profiles used in setting out the Works.

The survey equipment to be availed are:

Item Nr	Description	Unit	Quantity
	Supply, install, connect and set to work the following items of surveying equipment for the Engineer's office.		
1	Total Station (Theodolite WILD T1000, Distomat WILD DI5, data recorder WILD GRE4 or similar approved), notebook with surveying software RIB STRATIS, complete with tripod, carrying case and all accessories	nr	1

Item Nr	Description	Unit	Quantity
2	Level, Zeiss NI 2 automatic level, or similar approved, complete with tripod, carrying case and all accessories	nr	1
3	Levelling staff, engine divided 4 m long, folding, including staff level	nr	2
4	Staff levelling plate	nr	2
5	Fiberglass, PVC coated tape, 30 m length	nr	1
6	Steel hand tape, 5 m long	nr	4
7	Ranging rod, 3 m length	nr	5
8	Arrow, 400 mm length	nr	10
9	Conical plummet, 200 g weight (Plumb Bob)	nr	1
10	Spirit level with aluminium body, 1 m long Torpedo	nr	1
11	String line, 50 m long	nr	1
12	Hammer, 3 kg weight	nr	1
13	Hand shovel	nr	2
14	Pedometer, measuring to 10,000 m at 0.1 m intervals	nr	1

11.1.5 Vehicle and Transport:

Employer to provide as appropriate

11.1.6 Vehicle Operation and Maintenance

The vehicles provided shall be maintained at all times in good running order. Should any vehicles at any time become, in the opinion of the Engineer, unserviceable by normal use in the conditions and demands of the Site, the Contractor shall replace them without delay. If the Contractor fails to provide replacement transport, the Engineer shall be entitled to withhold the issue of a Payment Certificate until such time as a replacement is provided.

The Contractor shall provide all necessary fuel, lubricants, etc., and shall bear all expenses in connection with running, servicing, maintenance, repairs, upkeep, licensing and insurance. All vehicles shall be serviced, maintained and repaired at the supplier's workshop.

Insurance for all vehicles shall be 'comprehensive' for the replacement value of each vehicle and shall also include:

- Cover for the Engineer and his staff driving the vehicle, and for any other persons that the Engineer requires to be included; and
- Liability to third parties (including passengers whether the Engineer, his staff or others) for an unlimited indemnity in respect of death or personal injury and for the maximum indemnity reasonable in respect of loss, destruction or damage to property.

When not used by the Engineer the Contractor shall provide adequate and secure garaging for each vehicle and will not permit use of any vehicle other than that authorized by the Engineer.

The Contractor shall provide similar replacement vehicles whenever the original vehicles are not available for use for whatever reasons.

On completion of the Works, all the vehicles shall be handed over to the Employer. The Contractor shall be responsible for the running, servicing, maintenance, repairs, etc. of one of the vehicles which shall be handed over to the Employer at the end of the Defects Notification Period.

Before the vehicles are handed over to the Employer, the Contractor shall first arrange for a complete overhaul of each vehicle to the satisfaction of the Engineer. The Contractor shall arrange for transfer of ownerships and registration in favor of the Employer and pay all costs and fees. The final complete overhaul of each vehicle, before it is handed over to the Employer, shall include:

- servicing of the vehicle;
- fitting the vehicle with new tyres, new spare tyre, and new battery(ies);
- repair of all dents;
- cleaning up and technical verification of all-important parts of the vehicle;
- replacement of the parts found damaged or worn-out;
- repair and/or replacement of worn-out or damaged seats, seat covers, and floor mats;
- spraying of the vehicle to the same original colour as directed by the Engineer.

All the Contractor's expenses and costs arising under this Clause shall be reimbursed against the rates and prices entered in the Bills of Quantities. Purchase costs will be paid upon delivering of the vehicles to the Engineer. Standing costs are on a number basis while operating costs will be paid according to the kilometres travelled as recorded on the vehicle odometers.

The standing costs will include items such as provision of the vehicles, insurance, registration, road taxes, delivery to Site, garaging and provision of temporary replacement vehicles. The rate will also include for the cost of the final complete overhaul, transfer of ownership and registration in favour of, and delivery of all vehicles to, the Employer.

The vehicle-month rate will include all day-to-day running expenses such as fuel and lubricants, routine servicing, maintenance including periodical provision of new tyres and batteries, repairs, including vehicle parts replacements, provision of drivers and their overtime.

The vehicles shall be provided within 120 days after the Commencement Date. Prior to the supply of the vehicles, the Contractor shall provide and maintain temporary similar vehicles starting from the Commencement Date. If the vehicles for the use of the Engineer and his staff are not supplied within the specified period of 120 days, the Contractor shall provide, at his/her own expense and cost, the temporary similar vehicles for the Engineer's staff.

11.1.7 Housing for the Resident Engineer's staff

None

11.2 Survey Assistance to Engineer

The Contractor shall provide a survey assistant and chainmen, as and when required by the Engineer for the duration of the Contract.

12. ENVIRONMENTAL, SOCIAL, HEALTH AND SAFETY

Refer to ESHS policy of Ministry of Water and Environment