# MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

## TENDER NO 054/2024/PMID/MCWAP2/RFB

## PART C3.1
## SPECIFICATION

### SECTION 29

# HYDRO-MECHANICAL PLANT

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# SECTION 29

# HYDRO-MECHANICAL PLANT

## 29.1 SCOPE AND DEFINITIONS

This Section deals with the design, manufacture, testing, delivery, off-loading on Site, installation and commissioning of all the Hydro-Mechanical Plant at the Abstraction Works / Diversion Works and Sedimentation Works. This document shall be read in conjunction with Section 28 – Mechanical General, Section 37 – Painting and Corrosion Protection and Section 48 - Tests on Completion. This Section takes precedence over Section 28 – General Mechanical if the two sections are in conflict.

This Section shall be interpreted as Employers requirements with regard to the Contractors design obligations.

### 29.1.1 Scope

This Contract includes the items listed below which are also described in this Section:

a) The design, supply of all materials, manufacture, shop assembly and testing, corrosion protection, delivery, off-loading on Site, storage and installation at Site, Site painting and pre-commissioning of the Works items listed below:

   i) Boulder Scour Gate: 1 of, 4 m wide x 4 m high radial gate (hydraulically operated);

   ii) Gravel Scour Gate: 2 of, 4 m wide x 4 m high radial gate (hydraulically operated);

   iii) Stop Logs (for isolation of radial gates): 3 of 4 m wide x 4 m high sluice gates (manually operated);

   iv) Sluice Gates (downstream end of sand trap): 4 of, 2.7 m wide x 2.5 m high Channel Gate (hydraulically operated);

   v) Stop Logs (for isolation of sand traps): 2 of 2.7 m wide x 2.5 m high sluice gates (manually operated);

   vi) Sluice Gate (downstream end of Flushing Canal): 1 of 3.0 m wide x 3.0 m high Channel Gate (hydraulically operated);

   vii) Trash Racks: 4 sets of, 3.82 m wide x 13.3 m high (manually operated);

   viii) Fine Screens: 4 of, 2.7 m wide x 4.5 m high (manually operated);

   ix) Trash skip: 1 off, 4 $m^3$ capacity;

   x) Sluice Gates: 10 of, 1.5 m wide x 1.5 m high Channel Gate (all-sides sealing, Vertical Twin-lift Type, electrically operated); and

   xi) Access ladders, walkways and platforms for operation and maintenance purposes as provisionally indicated on the Drawings, in liaison with the designer of the Gates.

b) The following Drawings outline the general requirements of the gates and screens. The Contractor shall develop the detailed design of the Plant components in each case, within the space and layout constraints indicated by the Drawings and in accordance with the overall requirements of the Specification. The proposed installations are shown on the following Drawings:

   i) Drg. No. 2B-C7-200 : Abstraction Works - Overall Structural Layout;

ii) Drg. No. 2B-C7-201 to 209 : Diversion Works;

iii) Drg. No. 2D-C7-008 : Sedimentation Works – Plan Layout Portion 2; and

iv) Drg. No. 2D-C7-010 : Sedimentation Works – Cross Sections.

The detail design shall take into account, inter alia, all of the operating and maintenance requirements and physical conditions at the Site in addition to the operating and climatic conditions prevailing at the Site as set out in Section 1 - General and Section 28 - Mechanical General.

c) The supply of the Plant with all necessary items to provide complete working installations including all built-in parts and anchors, rail tracks, covers and frames, operating gears, control, monitoring and safety devices, actuators and electrical control panels from and including the main isolating switch on the incoming supply.

d) The manufacturing, testing and inspection of all Plant components complying with the imposed Project Quality Control Plan hold points.

e) All construction work in forming and preparing box outs chases etc., to receive the built-in parts and in placing concrete around them or grouting-in base plates and holding down bolts and the like. It also includes the complete installation of all Plant components to make them fully operational.

f) The adjustment and testing of the installed hydro-mechanical Plant until it has been taken over. During the entire testing (and pre-commissioning) period, the Contractor shall be wholly responsible for the preservation, care and remedying of any defective parts of the hydro-mechanical Plant. The Contractor shall provide all labour, supervision, guarding, apparatus, materials, stores, lifting equipment, instruments etc., necessary for the effective conclusion of these obligations.

g) The provision of access to the Engineer for observation and monitoring of the erection, installation and testing of all hydro-mechanical Plant. The Contractor shall ensure that specialist personnel that may be required, are on standby over the entire planned duration of the tests, and shall make contingency plans to remain present in the event that the tests over-run their expected duration.

### 29.1.2 Definitions

For the purpose of this Section:

a) **"Design"** includes, as applicable, the submission of design documentation for approval by the Engineer and the obtaining of approval for such design.

b) **"Manufacture"** includes, as applicable, the purchase of materials or goods, manufacture, fabrication and assembly, any specified corrosion protection measures and any off-site inspection or testing of materials or parts.

c) **"Supply"** includes, as applicable, the purchase of materials or goods, manufacture and fabrication, any specified corrosion protection measures and all required off-site inspection or testing.

d) **"Installation"** includes, as applicable, all handling and transport from storage, erection and aligning of Works.

e) **"Manual Operation"** shall refer to the handling, removal and (re)installation of the Plant by means of a grapple, crane and/or hoist (local).

f) **"Factory Acceptance Test (FAT)"** shall refer to all tests done on Plant or Plant items at the factory to ensure its functionality.

g) **"Pre-commissioning"** shall refer to the functional field test done on specific part of Plant on Site. This forms part of Test on Completion as specified in Section 48.

h) **"RL"** means reduced level in metres.

i) **"Water path"** shall refer to the distance along the surface of a material embedded in concrete but exposed to water measured from the concrete surface.

## 29.2 REQUIREMENTS

### 29.2.1 General

a) The Engineer shall be allowed and assisted by the Contractor to conduct full quality control during manufacture and installation. After installation at Site, all gates, racks and screens shall be commissioned by the Contractor in the presence of the Engineer.

b) All lifting equipment required for the installation at Site shall be provided by the Contractor. The Contractor or his representative shall supervise the off-loading of the Plant at Site.

c) The Contractor shall communicate and arrange the exact date of delivery at least 2 weeks in advance with the Engineer. Plant arriving at Site on a Friday shall be off-loaded the following Monday unless previous arrangements have been made with the Engineer.

d) All the necessary timber beams and sawdust bags to support the Plant (both at his Works and on Site), shall also be provided by the Contractor.

### 29.2.2 Boulder Scour Gate (Radial)

The Boulder Scour Gate is located adjacent to the Diversion Weir and in the boulder trap canal and is used to scour the boulder trap. The gate shall be operated by hydraulic cylinder for which the hydraulic power shall be supplied by one of the power packs situated in a Control Room located adjacent the Low-Lift Pumping Station which will service all the radial and upstream channel gates in the pump canals. Stoplog grooves shall be provided in the concrete wall upstream as well as downstream of the Boulder Scour Gate as indicated on the Drawings.

The Boulder Scour Gate shall be supplied as described below and as indicated on Drawing No. 2B-C7-201, complete with hydraulic cylinder, built in parts, hoist beam, control gear and operating Plant:

a) The radial gate shall close a clear opening of 4 m wide x 4 m high;

b) The gate shall be designed to withstand a differential head of 2 m of water across the gate;

c) The gate skinplate shall have a radius of 6 m;

d) The trunnions shall be situated 4 m above the sill level;

e) One double acting hydraulic cylinder shall be used and shall be attached to each gate;

f) The stroke of the cylinder shall be such that the gate is fully raised when the piston is fully retracted, and that the gate seats on the sill with sufficient force to supply seating pressure for the sill seal when in the fully extended position. The clevis shall be adjustable on the rod for this purpose;

g) The gate structure shall be manufactured from 3CR12 except as provided for below and painted according to Clause 29.10;

h) The gate shall be able to operate at any head up to the maximum differential head and at any opening between fully open and fully closed. The minimum opening shall be specified by the designer but shall not be more than 150 mm from the sill;

i) The opening and closing speed of the gate shall be approximately 0.5 m/min;

j) The trunnion bearings shall be self-aligning;

k) A dogging device shall be provided to lock the gate in the raised position. The pin shall be lockable in the fully extended and retracted position;

l) The dogging device shall be hydraulically interlocked with the main cylinder to prevent lowering of the gate in the dogged position;

m) The skinplate of the gate shall be of pickled and passivated Grade 316L stainless steel;

n) The vertical side plates of the gate shall be manufactured from stainless steel Grade 316L if they are closer than 300 mm to the side walls;

o) The gate shall have an upstream sealing arrangement to seal off the opening as indicated on the Drawings;

p) A seal wetting system shall be supplied to lubricate the seals of the gate during dry operation. This system shall be manually selected on the control panel when required;

q) The sealing and sliding surfaces shall be of Grade 316L stainless steel;

r) The guide rollers shall be situated downstream of the side seals;

s) Sealing shall be as specified in Clause 29.5.4;

t) The controls are specified in Clause 29.8; and

u) The hydraulic system is specified in Clause 29.9.

### 29.2.3 Gravel Scour Gates (Radial)

The Gravel Scour Gates are located at the downstream end of the gravel trap canals and are used to scour the gravel traps. The gates shall be operated by hydraulic cylinder for which the hydraulic power shall be supplied by one of the power packs situated in a Control Room located adjacent the Low-Lift Pumping Station which will service all the radial and upstream channel gates in the pump canals. Stoplog grooves shall be provided in the concrete wall upstream of the gate as well as downstream of the Gravel Scour Gate as indicated on the Drawings.

The Gravel Scour Gate shall be supplied as described below and as indicated on Drawing No. 2B-C7-202 and 203, complete with hydraulic cylinder, built in parts, hoist beam, control gear and operating Plant:

a) The radial gate shall close a clear opening of 4 m wide x 4 m high;

b) The design differential water head across the gate shall be 2 m;

c) The gate skinplate shall have a radius of 6 m;

d) The trunnions shall be situated 4 m above the sill level;

e) One double acting hydraulic cylinder shall be used and shall be attached to the centre of each gate;

f) The stroke of the cylinder shall be such that the gate is fully raised when the piston is fully retracted, and that the gate seats on the sill with sufficient force to supply seating pressure for the sill seal when in the fully extended position. The clevis shall be adjustable on the rod for this purpose;

g) The gate structures shall be manufactured from 3CR12 except as provided for below and painted according to Clause 29.10;

h) The gate shall be able to operate at any head up to the maximum differential head and at any opening between fully open and fully closed. The minimum opening shall be specified by the designer but shall not be more than 150 mm from the sill;

i) The opening and closing speed of the gate shall be approximately 0.5 m/min;

j) The trunnion bearings shall be self-aligning;

k) A dogging device shall be provided to lock the gate in the raised position. The pin shall be lockable in the fully extended and retracted position;

l) The dogging device shall be hydraulically interlocked with the main cylinder to prevent lowering of the gate in the dogged position;

m) The skinplate of the gate shall be of pickled and passivated Grade 316L stainless steel;

n) The vertical side plates of the gate shall be manufactured from stainless steel Grade 316L if they are closer than 300 mm to the side walls;

o) The gate shall have an upstream sealing arrangement to seal off the opening as indicated on the Drawings;

p) A seal wetting system shall be supplied to lubricate the seals of the gate during dry operation. This system shall be manually selected on the control panel when required;

q) The sealing and sliding surfaces shall be of Grade 316L stainless steel;

r) The guide rollers shall be situated downstream of the side seals;

s) Sealing shall be as specified in Clause 29.5.4;

t) The controls are specified in Clause 29.8; and

u) The hydraulic system is specified in Clause 29.9.

### 29.2.4 Sluice Gates – Diversion Works Sand Traps

The Sluice Gates are used to scour the sand traps and shall be manually controlled using a hydraulic cylinder for which the hydraulic power shall be supplied by one of the power packs situated in a Control Room located adjacent the Low-Lift Pumping Station.

a) Four sluice gates shall be provided to seal off clear openings of 2.7 m wide x 2.4 m high as indicated on Drawing No. 2B-C7-206 on the downstream end of the sand traps and pump canals.

b) The maximum hydrostatic head on the gates shall be 10.8 metres against the closed gate before water will overflow and drown out the flushing canal.

c) Each sluice gate shall be locally controlled by a single vertical hydraulic cylinder mounted above each gate.

d) The stroke of the cylinder shall be such that the gate is fully raised when the piston is fully retracted, and that the gate seats on the sill with sufficient force to supply seating pressure for the sill seal when in the fully extended position. The clevis shall be adjustable on the rod for this purpose.

e) Each gate shall be locally operated using a mobile lever operated 3-way directional control valve with P to T open to tank. The valve to be mounted at handrail height at the operating platform at each cylinder (gate).

f) Each sluice gate shall slide in built-in stainless steel 316 L guides.

g) The design and installation procedure shall make provision for installing the gate and frame as a unit to ensure proper alignment, since the civil structure does not allow wide enough pockets to make provision for guide adjustment facilities.

h) Gate installation shall ensure that the centre of gravity of all the downstream gates are in line in order to facilitate the use of a single overhead crawl beam common for all the sluice gates during maintenance procedures.

i) The gate shall be guided to limit its motion in the up and down direction only. The design of the sluice gate shall make provision for devices to positively locate the gate onto / into the guide frames, preventing it from dislodging in any direction. Sufficient load bearing surfaces shall be provided.

j) The gates shall be manufactured from 3CR12 except as provided for above and painted according to Section 37 – Painting and Corrosion Protection.

k) Sealing shall be as specified in Clause 29.5.4.

l) The controls are specified in Clause 29.8.

m) The hydraulic system is specified in Clause 29.9.

### 29.2.5 Sluice Gate - Diversion Works Flushing Canal

The Diversion Sluice Gate is situated at the downstream end of the Flushing Canal and controls the flow rate of water into the Balancing Dam. The gate shall seal on the downstream side and be operated by hydraulic cylinder.

a) One Sluice Gate shall be supplied as indicated on Drawing No. 2B-C7-209 complete with hydraulic cylinder, control gear and operating Plant.

b) This gate shall close and seal a clear opening of 3 m wide x 3 m high and shall operate under un-balanced conditions.

c) The design water head above the sill shall be 10.8 m.

d) One only double acting hydraulic cylinder shall be used and shall be attached to the centre of the gate.

e) The stroke of the cylinder shall be such that the gate is fully raised when the piston is fully retracted, and that the gate seats on the sill with enough force to supply seating pressure for the sill seal when in the fully extended position. The clevis shall be adjustable on the rod for this purpose.

f) The gate shall be manufactured from 3CR12 except as provided for below.

g) The sluice gate shall slide in built-in stainless steel 316 L guides.

h) The bottom edge / sill of the gate shall be of stainless steel Grade 316L.

i) The gate shall be able to operate at any head up to the maximum and at any opening between fully open and fully closed. The minimum opening shall be specified by the designer but shall not be more than 150 mm from the sill.

j) The opening and closing speed of the gate shall be 0.5 m/min.

k) Dogging devices shall be provided to lock the gate in the raised position. The pins shall be lockable in the fully extended and retracted position.

l) The dogging devices shall be hydraulically interlocked with the main cylinder to prevent lowering or raising of the gate in the dogged position.

m) A seal wetting system shall be supplied to lubricate the seals of the gate during dry operation. This system shall be manually selected on the control panel when required.

n) The fixed sealing and sliding surfaces (guides) shall be of Grade 316L stainless steel.

o) The gate wheels shall be manufactured from Grade 316L stainless steel.

p) Sealing shall be as specified in Clause 29.5.4.

q) The controls are specified in Clause 29.8.

r) The hydraulic system is specified in Clause 29.9.

s) The gate shall be painted according to Clause 29.10.

### 29.2.6 Sluice Gates – Sedimentation Works

The Sluice Gates are used to isolate the sedimentation canals, Balancing Reservoir Feeder Pipe and Flushing Pipe and shall be manually controlled using an electrical operating system at each gate.

a) Eight (8) of sluice gates shall be provided to seal off clear openings of 1.5 m wide x 1.5 m high as indicated on Drawing No. 2D-C7-010 on the upstream end of the sediment canals.

b) Two (2) of sluice gates shall be provided to seal off clear openings of 1.5 m diameter as indicated on Drawing No. 2D-C7-008 on both ends of the feeder chamber.

c) The maximum hydrostatic head on the gates shall be 5.48 metres.

d) Each sluice gate shall be manually controlled by a single vertical electrical actuator mounted above each gate and accessible from an operating platform / walkway adjacent to the gate.

e) Each sluice gate shall slide in built-in stainless steel 316L guides.

f) The design and installation procedure shall make provision for installing the gate and frame as a unit to ensure proper alignment.

g) Gate installation shall ensure that the centre of gravity of all the downstream gates are in line in order to facilitate the use of a single crawl beam common for all the sluice gates during maintenance procedures.

h) The gate shall be guided to limit its motion in the up and down direction only. The design of the sluice gate shall make provision for devices to positively locate the gate onto / into the guide frames, preventing it from dislodging in any direction. Sufficient load bearing surfaces shall be provided.

i) The gates shall be manufactured from 3CR12 except as provided for above and painted according to Clause 29.10.

### 29.2.7 Stop Logs

a) The downstream stop logs for the Boulder and Gravel Scour Canals to be designed that it can be stacked in order to obtain the required height and limit the weights for it to be handled by the Portal Crane (Boulder and Gravel Scour Canals) which will place it in position.

b) The design of the Boulder and Gravel Scour Canal stop logs' sealing arrangement to allow for stacking of the stop logs.

c) Boulder and Gravel Scour Canal Stop logs must be able to be stacked in any possible sequence.

d) Stop logs be manufactured from mild steel.

e) The stop logs must be transportable by means of a heavy vehicle.

f) Have a lifting device for handling by the portal crane (Boulder and Gravel Scour Canals) and monorail (Sand Trap Canals).

### 29.2.8 Trash Racks and Fine Screens

#### 29.2.8.1 Description

The purpose of the trash racks and fine screens are to screen water entering the sand trap and pump intake canals of the Low-Lift Pumping Station. The trash racks are situated in front of the fine screens as indicated on Drawing No. 2B-C7-206, and used to prevent large floating debris from entering the canals.

a) Raising and lowering of the racks and screens shall be manually controlled by a grapple beam suspended from the portal crane and crawl beam respectively and accessible from an operating platform / walkway adjacent to the rack or screen.

b) Separate trash rack units will be stacked directly on top of other in guides installed in the Diversion structure and shall cover the full height from RL 897 up to RL 909.15. Four operational sets shall be supplied.

c) Four operational fine screens shall be supplied.

d) The trash racks and screen panels shall be designed as fixed, light weight interchangeable Grade 316 L stainless steel units, typically as indicated on the Drawings.

e) All supports required to keep the trash rack and fine screens rigidly in position shall form part of the supply.

f) The racks and screens shall be manually cleaned by means of raking or after being lifted onto the deck at RL 909.15.

g) The normal operating draw-off through the trash racks and fine screens will be 5 $m^3$/s and 2 $m^3$/s respectively.

h) Corrosion Protection according to Clause 29.10.

#### 29.2.8.2 Rack and Screen frames

a) The trash racks and fine screens shall have frames manufactured from stainless steel Grade 316L sections, manufactured from rolled plate.

b) Each frame shall be fitted with four parallel guide stubs manufactured from Nylatron GSM which shall slide freely in the guides as indicated on the Drawings. Guide stubs shall be mounted close to the corner on the vertical sides of the frames and are not required to rotate.

c) Special care shall be taken to ensure that the fully assembled racks and screens are flat and that the sides of the frames are square and parallel to one another. The squareness tolerance of ± 2 mm diagonally across corners and the flatness tolerance of 2 mm shall be strictly adhered to and no deviation from this Specification shall be permitted unless authorised by the Engineer in writing.

d) Screens shall be designed for a differential head of 1.5 m of the full area of the screen.

e) Each frame shall have debris collecting trays on at least two different levels on its upstream side which shall prevent any debris from falling down to the bottom of the screen and canal.

f) Water shall drain freely from the screen frame and trash collecting trays.

g) Each frame shall be designed in such a way that it can only be installed in the guides in the correct orientation.

h) All supports required to keep the trash rack and fine screens rigidly in position shall form part of the supply.

i) The maximum height of a trash rack shall not exceed two meters to facilitate easy cleaning.

#### 29.2.8.3 Screen slats

a) All slats shall be manufactured from stainless steel Grade 316 L and shall fit accurately into the stainless steel frame.

b) Slats shall be vertically mounted.

c) All sections shall be homogeneous and free of any defects, burrs or flaws and shall have a smooth surface.

d) The trash rack openings shall be 40 mm and the bars shall be 50 deep x 10 mm wide.

e) The fine screen slats shall conform to the following dimensions: width of slat: 16 ± 2 mm and width of gap between slats: 25 ± 2 mm.

### 29.2.9 Trash Skip

a) A trash skip with lockable steel wheels shall be supplied, capable of being hand-manoeuvred on the deck, above the gravel and sand traps when filled with trash. The wheels shall be suitable for extended periods of exposure to the elements without suffering any material or lubrication degradation.

b) The trash skip shall be of 4 $m^3$ capacity and manufactured from a robust 304L steel construction and rubber lined to the satisfaction of the Engineer.

c) The trash skip shall be equipped to be emptied onto a road vehicle by using the portal crane.

d) Proper provision for drainage of water shall be made in order to keep down the weight of the trash filled skip.

e) Corrosion protection according to Section 37 – Painting and Corrosion Protection.

### 29.2.10 Operating Conditions and Climate

For water quality reference should be made to Section 28 – Mechanical General and for climatic conditions reference should be made to Part C4, Section 4.3 for Hydrological Data.

### 29.2.11 Drawings

Drawings shall be in accordance within the requirements as set out in Section 28 – Mechanical General.

### 29.2.12 Design Requirements

The particular requirements of the Gates are as follows:

a) During installation, proper care shall be taken to facilitate alignment and matching of corresponding surfaces as well as drop tight sealing of each gate against its sealing frame when the gates are in a closed position;

b) The bottom sealing face of the sealing frame shall allow for unobstructed flow without allowing stones or other debris to gather in the sealing frame or on the sealing face;

c) The gate design shall include rubber seals, which shall be from EPDM rubber or equal;

d) The gates shall be guided to limit their motion to the up and down direction only. In each, the design of the sluice gates shall include devices to positively locate the gate in the guide frames, preventing it from dislodging in any direction. Sufficient load bearing surfaces shall be provided. The tandem shaft and spindles must be utilised to ensure alignment of the slide as it is raised or lowered;

e) The sluice gates in fully raised position shall clear the full opening to allow unrestricted flow;

f) The gates shall be designed to operate in fully submerged conditions during normal operation;

g) The gates shall be able to operate at any head up to the maximum and at any opening between fully open and fully closed;

h) During operation, the bottom of the gates (slides) shall be at the same level as the top of the opening when in the fully raised position allowing unobstructed flow through the gateway;

i) The gates shall be installed in such a manner that the skin plates shall always be on the wet side when in the closed position;

j) The complete channel gate assembly shall be fabricated from stainless steel grade 316L or better and corrosion protected as specified in Clause 29.10 of this Section; and

k) The gates shall be clearly identified with the manufacturer's nameplates giving Contract No., year of manufacture, sluice no., mass in kg, maximum hydrostatic head, material used and all necessary information relating to the supply and replacement parts. These nameplates shall be manufactured from stainless steel, mounted on the sluice gate by means of stainless steel screws or stainless steel rivets.

After manufacture (but before dispatch) the gate (complete with all associated and contiguous components including waterway liners) shall be fully assembled in the workshop to allow for witnessed, comprehensive fit-up and operational checks by the Engineer.

### 29.2.13 Permissible Stresses

Permissible design stresses shall comply with the requirements as specified under Section 28 – Mechanical General.

## 29.3 BUILT IN PARTS

### 29.3.1 General Requirements

a) Those parts of the Works that are required to be built into the concrete structure with precision (e.g. base plates, frames etc.), are referred to herein as "second stage built-in parts".

b) In order that the second stage built-in parts may be rigidly supported during construction, installation, they shall be secured by means of adjustable bolts and the like to anchors, ties,

etc., already incorporated into the structure. These anchors, ties, etc., are referred to herein as "first stage built-in parts".

c) First stage built-in parts shall be built into the structure by the Contractor in accordance with Drawings and information supplied by the manufacturer of the Hydro-Mechanical Plant and to the approval of the Engineer.

d) The Contractor shall ensure that the manufacturer of the Hydro-Mechanical Plant signs off on the process for checking that the parts are built in by the Contractor with sufficient accuracy to comply with the designed functional requirements. First stage built-in parts shall have not less than two 6 mm diameter holes (suitably spaced) drilled in them so that the parts may be bolted or nailed to formwork to hold them securely in position during first stage concreting.

e) The Contractor shall ensure that first stage built-in parts are delivered to Site and that the Engineer receives the necessary drawings and information, by the dates shown on the approved programme.

f) The Contractor shall be responsible for the design, detailing, manufacture, corrosion protection, trial erection, transport, storage and supervision of embedding in first stage concrete of first stage built-in parts. The Contractor shall ensure the correctness of the line and level of such parts before (and checked after) the concrete has been placed, all to the satisfaction of the Engineer. The Contractor shall nevertheless ensure that first and second stage built-in parts are designed and manufactured in such a way that adjustment is possible between the first stage built-in parts and second stage built-in parts to allow precise setting of the latter.

g) Special attention shall be given to the safe installation of these items, taking into consideration that safe temporary working platforms and safety harnesses will be required as well as any other safety precaution as stipulated in Section 2 - Occupational Health and Safety.

h) All first stage anchor plates for building into the primary concrete shall be provided timeously according to the approved programme. All second stage anchor bolts / bars and adjusting nuts shall be provided for the gate sealing frames and guide sections.

i) Second stage anchor bolts / bars shall be a minimum of 16 mm diameter and shall be welded to the anchor plates to enable accurate adjustment and alignment of the frame and guide sections to be made. The anchors shall be arranged to ensure that no movement of the members occurs during placing of the secondary concrete around them. The design of first and second stage built-in parts shall reflect the forces that will be applied to them in service. In the case of heavily loaded first stage built-in parts, anchor rods shall not be “spot” welded to plates but set into holes drilled through the plates and then welded on both sides (or secured by such other means as are acceptable to the Engineer).

j) All welds on built-in parts, including those between adjusting bolts and first stage anchors, shall be adequate to develop the full strength of the abutting members in order to resist separation of the built-in parts from the surrounding first and second stage concrete and of the adjusting bolts from the first stage anchors.

k) All first and second stage built-in parts shall be arranged so as to allow the proper placing and compaction of concrete and eliminate any air voids around the embedded parts. They shall be suitably shaped to allow fixing of reinforcement in second stage concrete generally as shown on the Drawings.

l) All permanently immersed built-in parts in contact with water, or where maintenance painting is not possible, shall be of Grade 316L stainless steel up to a water path of 150 mm. All parts covered in concrete but within 50 mm of the surface shall also be considered to be in contact with water and be treated as above. Nuts, bolts and washers of second stage built-in parts which will be subject to an exterior environment in the completed Works shall be stainless steel.

m) All first stage built-in parts shall be coated with a hold primer to prevent corrosion of the parts until such time that the second stage built-in parts can be erected and cast in.

### 29.3.2 Restriction on Time of Loading of Built-in Parts

Built-in parts shall not have any loads applied to them earlier than the latest date of either:-

a) 7 days after completion of epoxy grouting; or

b) 28 days after completion of first stage or second stage concreting in or such earlier date as may be approved by the Engineer; and

c) The Contractor shall ensure that under no circumstances during the casting in of any primary or secondary concrete are loads transferred to the built-in parts.

## 29.4 GRAPPLE

a) Automatic type grappling beams shall be used to handle the stoplogs, trash racks and fine screens by means of the portal crane and mono-rail (see Section 31 – Cranes, Hoists and Winches) on top of the deck.

b) Two grappling beams shall be supplied; one to handle the stop logs (Radial Gates) and the second to handle the sand scour stop logs, trash rack and fine screens. Each grappling beam shall be designed to safely handle the heaviest of the loads that it will be required to lift.

c) Each grapple shall be suspended from the portal crane or mono rail with a single stainless steel lifting pin, designed in such a way that it will centralise the crane hook.

d) The main body of each grapple shall be 3CR12.

e) The grapple hooks shall have welded on stainless steel liners on all edges that will come into contact with the equipment being lifted or may be manufactured complete from stainless steel 2204.

f) The grapple hooks shall automatically engage into slots in the equipment being lifted when lowered onto these.

g) Each grapple shall, both in the loaded and unloaded condition, hang plumb when suspended from the portal crane.

h) When the weight of the Plant suspended is taken off the grapple hooks, the grapple shall automatically disengage from that specific piece of Plant.

i) Stainless steel resting plates shall be installed on the points of contact when the grapple rests in the unloaded condition on top of the equipment being lifted.

j) Each grapple shall run freely on Nylatron GSM or Vesconite guide rollers inside the same built-in guides as the Plant that it is handling. The guide rollers shall run on stainless steel axles and shall be an integral part of each grapple, supporting it in the direction of flow and across it.

k) When not in use, each grapple shall be stored by means of integrated stainless steel storage pins on the top end of its guides. Each storage pin shall be provided with a stainless steel lock pin to lock it either in the “storage” or “operation” position.

l) While in the storage position, no part of the grapple shall interfere with the egg crate grating on RL 255 covering the shafts in the Intake Tower.

m) All bushes shall be stainless steel, the inside of which shall be cleared of paint after corrosion protection.

n) All pins / axles shall be of stainless steel Grade 316 or EN57. Any deviations shall be communicated to the Engineer in writing.

o) To minimise maintenance, no ball or roller bearings shall be acceptable.

p) All grapple motions of the completely assembled grapple shall at all times be able to move freely, both inside and out of water.

q) The grapple shall after manufacture and assembly be straight and true to the dimensions specified and accepted by the Engineer.

## 29.5 DETAILS OF GATES

### 29.5.1 General

a) Gate bodies and non-detachable parts shall be welded constructions. All welds shall be continuous with no crevices.

b) The minimum thickness of the radial gate skin plate shall be 12 mm.

c) Gate (slide) shall consist of a flat plate reinforced with structural or formed members welded to the plate.

d) The gates shall be designed in such a manner that water retention areas are avoided. Where this is not possible drainage holes shall be provided to prevent water retention which shall be a minimum of 50mm in diameter. The design shall avoid areas and profiles that are difficult to paint. Where this is unavoidable the areas shall be boxed and seal welded to the satisfaction of the Engineer.

e) All edges and corners shall be radiused and polished for smooth operation within the guide seal assembly.

f) Parts that are difficult to reach after installation or that require “frequent” disassembly (as determined by the Engineer) shall be manufactured from Grade 316L stainless steel.

g) No threaded holes into mild steel shall be allowed. Threaded holes shall be avoided where possible and where unavoidable shall be into stainless steel 316L.

h) All axles or moving parts shall be from stainless steel Grade 316L, EN57 or other suitable corrosion resistant steel as approved by the Engineer. All mating surfaces shall also be from stainless steel.

i) Preferably, all bushes and bearings shall be self-lubricating or of no or low maintenance.

j) Guide rollers fitted to the gates shall be of a suitable proven corrosion resistant material and fitted with self-lubricating bearings. Should guide blocks be used instead of the rollers these shall be made of a suitable self-lubricating polymer.

k) The gate wheels shall be manufactured from stainless steel Grade 316, EN57 or better and fitted with self-lubricating bearings where possible.

### 29.5.2 Sealing Frames and Guides

a) Sealing frames shall consist of upstream, downstream and side guides and side-, sill- and lintel sealing members where appropriate.

b) Gate frames shall be of the self-contained embedded channel mount type.

c) Gate guides of all channel and sluice gates shall extend to operating deck level or such, that when the gates are fully opened, the bottom of the gates (slides) shall clear the opening.

d) Guides shall be designed and constructed to withstand the total thrust caused by water pressure.

e) All sealing, sliding and running surfaces shall be of stainless steel, Grade 316L or better. The sealing frames and guides shall also be of stainless steel Grade 316L plate and sections and shall be fabricated so as to give a rigid structure.

f) All sections shall be perfectly straight, flat, square and true after manufacture and corrosion protection to the dimensions given on the Drawings. The straightness tolerance shall be 1 mm in 1 m to prevent unequal pressure or leakage. The squareness tolerance of ± 2 mm diagonally across the corners shall be strictly adhered to and no deviation from these specified dimensions shall be permitted unless authorised by the Engineer in writing.

g) All guide members of a specific set shall be bolted together in sequence at the Manufacturer's Works for inspection and, after approval by the Engineer, each individual guide member shall be marked by hard stamping with corresponding numbers in order for them to be installed in the same sequence.

h) All sealing, sliding and rolling surfaces shall be smooth, with no steps or misalignment at the joints between adjacent guide sections.

i) The bottom seal shall be of the flush bottom closure type and shall be compressible rubber at the invert of the opening and extend into the side guides forming a complete seal for the entire width of the gate. The gate frame lower member shall be furnished with a specially shaped polymer seal and loading pad. The bottom edge of the gate (slide) shall have integrally formed reinforcement and have gently ramped lead-in surface to prevent damage to the seal.

j) Special attention shall be given to the aligning and adjusting of these surfaces and safe temporary working platforms and safety harnesses shall be used for installing these items in order to achieve this.

k) For any load bearing roller paths, sealing frames shall have thick stainless steel plate of adequate size to transmit the wheel loads to the supporting frame and concrete.

l) A clearance of 5 ± 1 mm shall be allowed, in the direction of flow, between the inner surfaces of each guide member and the gate / fine screen element running in it. Across the direction of flow, this lateral clearance shall be minimum 6 mm and maximum 10 mm.

### 29.5.3 Yoke

a) The yoke to support the operating bench stand shall be formed by two structural members welded or bolted to the frame extensions to form a one piece rigid frame.

b) The yoke shall be fabricated from stainless steel grade 316L and all fasteners shall be stainless steel grade 316.

c) The gate (slide) shall be removable through the yoke opening or by disassembly and removal of the yoke.

d) Yoke members shall be designed for maximum output of the gate hoist mechanisms.

### 29.5.4 Seals

a) The gate shall be provided with appropriate sealing to ensure that when the gate is in a closed position against maximum water pressure, leakage past the seal shall not exceed 0.1 ℓ/sec/metre seal length.

b) All seals shall be easily replaceable without having to remove the gate (slide).

c) Corners or intersections of seals and bearing strips shall be prefabricated to ensure they are interlocked and sealed. Seal corners shall be pre-moulded with no joints at or within 200 mm of a corner in order to provide leak-proof joints.

d) Shop joints shall be vulcanised and shall avoid feather-edges on the sealing surface. Field joints shall be minimized, accurately machine cut, carefully butted to provide interference fits, joined by a cold curing epoxy, and held with double fasteners on each side of the joint.

e) Rubber seals and bearing strips shall be manufactured in South Africa and have the following physical characteristics as tabled in Table 29/1 overleaf:

**TABLE 29/1**
**CHARACTERISTICS FOR RUBBER SEALS**

| PHYSICAL PROPERTIES | UNITS | MATERIAL | |
|---|---|---|---|
| | | EPDM (ETHYLENE PROPYLENE DIENE MODIFIED) | NEOPRENE (HIGH STRENGTH) |
| Density | $g/cm^3$ | 1.2 | 1.47 |
| Durometer Hardness (Shore A) | | 55/65 | 55/65 |
| Tensile Strength:<br>– Initial<br>– After aging 14 days at 70°C in air | MPa<br>% | 10<br>< -20% | 10<br>< -20% |
| Tear Strength:<br>– Initial<br>– After aging 14 days at 70°C in air<br>– Elongation at break | MPa<br>%<br>% | >10<br>< -20%<br>> 350 | >10<br>< -20%<br>>300 |

Bearing Strips:

i) Material : Ultra-high Molecular Weight Polyethylene (UHMW-PE).
ii) Specific Gravity : 0.93.
iii) Tensile Strength : 21.4 MPa.
iv) Water Absorption : 0.01% (in 24 hrs).
v) Elongation at break : > 300%.
vi) Shore hardness : 62 – 66.
vii) Coefficient of Friction : 0.15 – 0.20.

f) Dimensional tolerance of the seals shall comply with ISO 3302, unsupported extrusion class E2.

g) Normal dimensions:

- 10 to 16 mm : ± 1 mm
- 16 to 40 mm : ± 1.3 mm
- 63 to 100 mm : ± 2 mm

h) The lashing strips shall be clearly marked (numbers to be welded on) to indicate their correct position relative to the gate - hole alignment. The bolt holes in the seals shall be drilled in the factory and the seals shall be marked to indicate their correct position with respect to alignment of holes.

i) The lashing strips shall be manufactured from stainless steel grade 316L and shall not join at the same points as that of the rubber seal joints.

j) All bolts and fixings for the seals shall be stainless steel grade 316. Countersunk head screws shall be of the Allen key type. 1 mm thick Nylon 6E washers shall be used under all countersunk screw heads. Dubo washers shall be used under washers and nuts.

### 29.5.5 Channel Gate Operating Gear Mechanism (Sedimentation Works)

a) Operating gearboxes (both drive and driven gearboxes) shall be secured to the top of the head frame bridge (yoke) with actuator approximately 1000 mm above the operating floor level.

b) The two lifting geared mechanisms shall be interconnected via a tandem shaft manufactured from stainless steel grade 316L. Shafts, gears and other rotating components shall be supported on heavy-duty roller bearings to provide the highest possible efficiency. All bearings and gears shall be totally enclosed in weather tight housings and provided with a seal on the input shaft of the gearbox to prevent water from entering the gearbox.

c) Geared operating mechanisms shall be furnished with a threaded bronze lift nut to engage the threaded portion of the rising spindles.

d) An electrically operated gearbox shall be provided with a gear ratio as required to ensure a rim pull at the handwheel of the actuator of between 100 and 150 N under full unbalanced head.

e) Each slide gate shall be equipped with two rising operating spindles (stems) manufactured from stainless steel grade 316L with ‘Acme’ threads and shall be provided with adjustable stop collars to limit upward and downward travel after final installation and adjustments. After final adjustments of the stop collars, they shall be locked in position by means of stainless steel grub screws which shall fit into a drilled indentation in the operating spindles. Collars shall be fabricated from bronze or FRP bushing.

f) Spindles shall have a slenderness ratio (L/R) less than 200.

g) Linear position indicators shall be incorporated in the rising spindles weather protection column, indicating the position of the channel gate in 10% increments, from fully open to fully close.

h) Closure of the gates shall be through the clock-wise rotation of the actuator handwheel.

i) The direction of handwheel rotation to open and close the gate together with directional arrows shall be legibly cast in on the upper surface of the rim on the handwheel.

j) Provision shall be made for easy lubrication of the operating mechanism. Operation of the sluice gate must not be adversely affected by extended exposure to the elements and alternating dusty and humid conditions. Refer to Section 28 – Mechanical General for further details on the requirements of lubrication.

## 29.6 MANUFACTURING

### 29.6.1 Material

The materials for manufacture shall be as follows:

| | | |
|---|---|---|
| Gate (Slide) | : | Stainless Steel Grade 316L. |
| Sealing Frames/Guides/Yoke | : | Stainless Steel Grade 316L. |
| Operating Tandem and Spindles | : | Stainless Steel Grade 316L. |
| Fasteners | : | Stainless Steel Grade 316. |
| Operator Housing | : | Cast Iron SANS 936/937 Grade SG42 or Cast Steel to BS EN 10293. |

For additional corrosion protection of various components refer to Clause 29.10.

Welding electrodes for stainless steel shall be of austenitic stainless steel grade 316 or as recommended by the material manufacturer and an approved welding authority.

All fasteners used for the Plant shall be stainless steel grade 316. All surfaces on fasteners shall be smooth and without jagged edges. They shall be pickled and repassivated after machining.

All material and Plant, where not specified, shall comply with relevant SABS or BS Standards.

All materials and Plant shall be new and of first grade quality.

All bronze shall be zinc free.

### 29.6.2 Drilling

All bolt holes, made during manufacture or on Site, shall be drilled, not punched.

### 29.6.3 Cutting

Edges of all plates and structural members shall be square, clean and free from burrs and true to dimensions. If flame / plasma cutting is employed, resultant edges shall be dressed smooth and true.

### 29.6.4 Bolts and Nuts

All bolts, nuts and washers shall be of stainless steel grade 316 (A4 to EN 3506) and shall comply with Section 28 – Mechanical General.

### 29.6.5 Welding

Welding shall be in accordance with BS and SANS Standards for non-corrosive steel and shall be in accordance with Section 28 – Mechanical General. The Contractor shall satisfy the Engineer that his welders are qualified in accordance with the welding specifications.

## 29.7 STORAGE, HANDLING AND TRANSPORT

The Contractor shall be responsible for the supervision of all loading and unloading procedures.

Coated components shall be handled with due regard for the relatively soft nature of organic coating and the appropriate precautions shall be taken.

The use of ropes, wire ropes or chains without suitable padding is expressly forbidden.

The Contractor shall provide all the necessary timber and sawdust bags used to support the components on soil, concrete or other hard surfaces and to separate them from each other, both at his Works and on Site.

When loading on to vehicles, precautions shall be taken to support and chock the components to prevent movement. Components shall be firmly lashed or chained with padded lashing, supported on sawdust bags. The area of padded surfaces shall be adequate to prevent damage to the coating.

Items may be inspected on arrival at the Contractor's end delivery point and any repairs necessary shall comply with all requirements of the Specification. The repair of all damage sustained during transport shall be for the Contractor’s account.

Stainless steel components shall be packed in a way that prevents contamination during transportation.

Storage, handling and transport of Plant shall further be in accordance with Section 28 - Mechanical General.

## 29.8 ELECTRICAL CONTROLS AND PLANT

### 29.8.1 Control Desk

The gates shall be controlled by a PLC and SCADA system (remote) and control panel (local) as required in terms of Section 40 – Control and Instrumentation General in the section dealing with the Vlieëpoort Diversion Works and relevant electrical Drawings.

The Control Desk shall consist of one complete set of controls and indicator lights as described below, as well as a display (HMI) unit. The display unit shall be used to access the service mode of the gates, to provide information as to what operation is underway, as well as to indicate the gate opening. The unit shall also display information concerning any fault that may occur and what may be done to remedy the situation.

Manufacture may only commence once the Engineer has approved the layout.

### 29.8.2 Controls of the Gates

a) The gates shall be controlled from local control desk(s) situated in Control Room(s) at the Vlieëpoort Abstraction Works or remotely from a SCADA screen situated at the Operation and Control Room at the High-Lift Pumping Station. The emergency stop pushbutton on the control desk and emergency close input from the SCADA screen shall override all modes of operation.

b) Emergency close input from the SCADA screen shall override all actions and close the gate even when the gate controls are in the local position. All subsequent operating commands on the gate shall require that the emergency command be cleared first.

c) All the gates shall be controlled and operated from two (2) control desks each with a hydraulic powerpack.

d) All controls shall be such that once the motion has been initiated it shall continue, even when the button is released. The continued motion of the gate, once the motion has been initiated, shall be automatically arrested at both the fully raised and fully lowered positions by limit switches. It shall be possible to change the direction of gate travel at any point of travel by pressing the STOP button first.

e) The open and close commands shall be provided with interlocks that prevent simultaneous initiation or the reversal of a given motion without the STOP button being pushed.

f) The key locks on all the control panels shall use the same key. Two keys for each type of lock shall be provided.

g) The sluice gates in the Diversion Works Sand Traps shall be locally operated from locations at each gate using a lever operated 3-position directional control valve.

### 29.8.3 Control Panel (Local control)

The control panel shall have one complete set of controls and indicator lights, as listed below, for operation of a gate.

#### 29.8.3.1 Controls and indicator lights

a) The whole control desk shall be lockable by a key-switch. The key shall be trapped in the UNLOCK position.

b) A key operated local / remote selector switch. The key shall be trapped in the local position.

c) One 400 V voltmeter with 4 position switch to indicate the potential over each phase.

d) One ammeter with 3 positions to indicate the current in each phase.

e) A RED coloured LAMP TEST button. This button shall be labelled accordingly and shall illuminate all the indicator lamps on the control desk when depressed.

f) A GREEN coloured push button shall be provided and labelled RAISE.

g) A GREEN coloured indicating light shall be provided and labelled RAISING. This indicating light shall illuminate only when the gate is opening.

h) A GREEN coloured push button shall be provided and labelled LOWER.

i) A GREEN coloured indicating light shall be provided and labelled LOWERING. This indicating light shall illuminate only when the gate is closing.

j) A RED coloured push button switch shall be provided and labelled STOP. This button shall arrest the movement of the gate and hold it stationary in that position.

k) A 50 mm diameter mushroom headed RED coloured emergency stop push button switch shall be provided and labelled EMERGENCY STOP. This switch shall be the push to latch – twist to release type. In the operated or pushed in position, the contacts of the switch shall break the circuit of the main contactor supplying all the circuits of the gate. This main contactor shall be on the supply side of the up and down motion operating circuit.

l) A RED coloured indicating light shall be provided and labelled SYSTEM UNAVAILABLE. This light shall illuminate when there is a fault with the system.

m) A digital position indicator linked to the limit switches displaying whether the gate is in an open or closed position.

n) A position switch to select the required gate set. Each position to be labelled according to the gate set selected, e.g.: Boulder Gate, Gravel Scour Gates A and B and Flushing Canal Sluice Gate.

### 29.8.4 Sensors

#### 29.8.4.1 Limit switches

a) For gates operated by hydraulic cylinders, limit switches shall be used only for the position indication of the lowered and raised positions. The control of the movement shall be by means of pressure switches.

b) The upper limit switch shall be made when the gate is raised, and the lower limit switch shall be made when the gate is in the lowered position.

### 29.8.5 Position Indicator

Position indication is not required for this Contract. When required it shall comply with the following requirements:

a) The position indicator shall be sealed to at least IP 68; and

b) Position indication to be accurate to the nearest 10 mm of gate opening.

### 29.8.6 PLC Interface

PLC I/O interface shall be as shown on the Drawings and I/O Schedule. Provision shall be made for position indication and remote control.

A terminal strip with potential free contacts for remote indication shall be provided as follows:

a) Ready;

b) Remote selected;

c) Local selected;

d) Gate select;

e) Pump running;

f) Open gate;

g) Gate opened;

h) Close gate;

i) Gate closed;

j) Emergency close;

k) High oil pressure; and

l) High temperature.

A 4 -20 mA position indication signal shall also be wired to this terminal strip.

## 29.9 HYDRAULIC OIL PLANT

The hydraulic Plant shall comply with BS 4575. The control and hydraulic Plant shall be neatly mounted in a desk type panel.

The hydraulic diagram and operating instructions shall be engraved on a stainless steel plate(s). All engravings shall be filled with black paint. This plate(s) shall be permanently fixed to a wall near the gate controls. The diagram shall not be smaller than A2 size and must be approved by the Engineer before manufacture.

### 29.9.1 Hydraulic Oil Reservoirs, General

a) Hydraulic oil reservoirs shall be of welded construction and all parts, wherever possible shall be manufactured from 304L stainless steel. Return oil shall be filtered prior to re-entering the reservoirs.

b) A removable lid, incorporating a watertight filler cap, shall be fitted to the reservoir and sealed with a gasket. See through inspection covers on the sides of the tank shall be provided for cleaning.

c) The capacity of the reservoir to normal top oil level shall be not less than twice (2x) the maximum cylinder capacity.

d) The reservoir shall be mounted on an angle iron support frame, 150 mm minimum from the wall, with stainless steel 304L legs fixed to the floor with M16 stainless steel wedge anchors.

e) The reservoir bottom shall slope 1% minimum with a drainpipe and transparent glass water trap at the lower end. The water trap shall be fitted with a stainless steel ball valve, 250 mm minimum from floor level for draining purposes and sealed with a taper plug.

f) A purpose built drip tray shall be supplied below the power pack and reservoir in order to catch any fluid spilled during servicing and minor breakdowns.

### 29.9.2 Hydraulic Oil Reservoirs, Plant

Hydraulic oil reservoirs shall be provided with:

a) A hydraulic fluid level indicator, mounted on the reservoir in such a way that it is clearly visible whilst working on the control panel. The minimum level, with all hoist cylinders extended, shall be indicated with a red line. The maximum and filling levels shall also be indicated and appropriately marked;

b) A low oil level alarm and pump motor trip;

c) A breather fitted with a 3 micron air filter having:

   i) A flow capacity to maintain atmospheric pressure within the reservoir at maximum system demand; and

   ii) A breath-out by-pass.

d) High oil temperature alarm and pump motor trip;

e) A minimess point connected to the tank return pipe for oil sampling; and

f) A separately pumped oil filtration and cleaning system shall be mounted to the reservoir. It shall filter the oil to 3 microns and remove the water entrapped in the oil. This system shall be connected to the bottom of the reservoir in the same manner as the pump suction line and have a return line on the opposite side. The system shall work on a timer to automatically clean the oil during long periods of no operation.

### 29.9.3 Hydraulic Oil Reservoirs, Connections

a) The oil draw-off connection shall be mounted horizontally not less than 150 mm above the base of the reservoir.

b) The filling connection shall be arranged such that oil may only be placed in the hydraulic reservoir via the filtration system.

c) Pipe and other connections to reservoirs shall be welded internally and externally.

d) Facings and tappings shall be provided where necessary for mounting instruments and other devices. Seals shall be compatible with the operating fluids for the full temperature range. The stainless steel pads shall be welded internally and externally to the reservoir walls.

e) A solid stainless steel manifold block shall be attached to the reservoir and all valves, filters and instruments shall be directly bolted to parts in the manifold. The only pipework permitted will be the connections between the pump and manifold block. It shall be possible to remove the manifold block, as a compete unit, from the hydraulic reservoir.

f) The manifold block shall be machined on all faces to which valves and other components are bolted so that no distortion is caused either in the manifold or valve component when assembled.

g) Pipe connections, clamps and fasteners for sub-plates, valves and all parts of the hydraulic system shall suit and be accessible by standard tools to allow proper assembly and dismantling of an item without the necessity to disturb or remove any other component or pipe.

### 29.9.4 Filtration

a) Full flow filters shall be inserted in each hydraulic circuit.

b) The filters shall be of the full synthetic type.

c) The filter shall have an outer spiral wrapping bonded to the filter element.

d) Each hydraulic circuit shall include a 3 micron pressure pipe filter with a minimum beta value of 1000.

e) All filter elements and bodies shall be suitable for the maximum circuit pressure including transient pressures.

f) All filter elements shall be the same size.

g) All filters shall be constructed and installed so that the filter elements may be changed without disturbing pipework and/or components and with minimal loss of oil.

h) All filters shall be fitted with inbuilt clogging indicators.

### 29.9.5 Hydraulic Pipework

a) Pipes for hydraulic power transmission and hydraulic control circuits shall be manufactured from seamless cold drawn stainless steel tubing.

b) Where the materials to be joined are suitable and where the joint is unlikely to require dismantling for any purpose the pipe joints shall be welded. Wherever possible welded joints shall be factory fabricated.

c) All couplings shall be of the double ferrule or compression type and of the same material as the pipes to be joined.

d) Compression couplings shall conform to BS 4368 and shall not be fitted closer to the start of a bend than four times the outside diameter of the tube being joined. Compression couplings shall be tightened in accordance with the manufacturer's fitting instructions.

e) Quick release self-sealing couplings shall be leak proof under positive and negative pressures and shall be provided with a screw-on dust-tight cap manufactured from the same material as the coupling body. Where appropriate an anti-seize lubricant shall be applied to dust cap threads.

f) Joints in pipework shall be located so that any length of pipework can be removed without disturbing other pipework, all subject to the approval of the Engineer.

g) Flanges shall be of a type subject to the approval of the Engineer. All flanges and coupling bolts shall be manufactured from corrosion resistant material compatible with the pipe, operating pressure, temperature and fluid. Flanged joints shall be arranged such that sealing faces are not damaged or distorted during coupling or re-coupling of the joint.

h) The ends of all pipes which are to be coupled using compression fittings shall be suitably rounded to prevent damage to the O-ring seals during assembly of the couplings.

i) Hydraulic pipework shall be designed for the appropriate operating pressure, including transient positive and negative surges, together with all gravitational, thermal and inertial forces.

j) All pipework, valves, joints, couplings, fittings and seals shall be compatible with the operating and flushing fluids used, for the full range of operating temperatures.

k) Where practicable, hydraulic systems shall be prefabricated and brought on to Site cleaned, complete and sealed.

l) Pipe runs, where appropriate, shall be designed for temperature variations and differential structural or plant movement. Movement as required shall be permitted through adjacent supports which shall not damage the pipework.

m) Pipework shall be labelled as per the hydraulic diagram.

n) Supports shall also be provided immediately before and after a bend or offset and immediately before a change to flexible hose.

o) On completion each section of pipework including hydraulic equipment, valves and the like shall be subjected for a period of not less than 8 hours to a test pressure of the appropriate relief valve setting. The test pressure shall not cause any part to be subjected to more than 70% of the yield stress of that part. The system shall be leak-free throughout the test.

p) All hydraulic pipework including control, drain and return lines shall be designed as pressure lines suitable for the maximum operating pressure in power transmission lines.

q) All pipes shall be supported in properly made clamps manufactured in high density polypropylene. Clamps shall not damage the pipe and shall be designed for the size of pipe being clamped and allow, where necessary, axial movement to take account of thermal expansion. Fixing bolts shall be stainless steel.

### 29.9.6 Valves

a) All Plant supplied shall be from a known and reputable company with South African representatives, i.e. Vickers, Bosch, Rexroth or Parker Hannifen.

b) All valves in hydraulic systems shall be of the highest quality. Valves shall be bolted to machined sub-plates to which pipework shall be permanently connected such that:

- Valve and sub-plates are supported on structures and not on pipework;

- Valves shall be bolted to sub-plates without causing distortion of the valve; and
- Valves shall be removed from the circuit for maintenance without disturbing the pipework.

c) As far as possible valves and pipework shall be designed such that assembly of the Plant is only possible in the correct manner.

d) Valves shall operate without vibration for all conditions of flow throughout the working range of pressure and temperature.

e) Shut-off, non-return and direction control valves shall seal off the appropriate fluid passages completely.

f) Directional control valves shall have the P port open to Tank in the neutral position when possible.

g) Shut off and direction control valves shall be provided with indicators showing clearly the position or degree of opening.

h) Where appropriate, poppet valves shall be used in preference to spool valves.

i) Valves shall have mounting dimensions complying with internationally accepted standards.

j) Valves shall be clearly and permanently marked with the manufacturer's name and type and size code.

k) All hand operated valves shall be fitted with a tamper-proof locking device.

### 29.9.7 Pressure Relief Valves

a) Pressure relief valves shall have provision for fine adjustment and shall be fitted with a tamper-proof locking device.

b) Pressure relief valves shall be capable of discharging the maximum design flow with a pressure variation not exceeding 5 % above and below the design relief pressure.

### 29.9.8 Non-Return Valves

a) Non-return valves shall have head loss characteristics for all conditions of flow compatible with the inlet pressure requirements of pumps for both directions of rotation of pump drive shafts.

### 29.9.9 Hydraulic Oil Pumps

a) The pressure and displacement continuous rating of each pump shall exceed by not less than 20% the most onerous requirement. Pumps which may be operated with unboosted inlet shall be used.

b) Gear type pumps shall be used. Pumps shall operate without vibration.

c) Pumps shall be suitable for full load application and continuous operation after being idle for not less than 40 days, and for operation on hydraulic mineral oil at ambient temperatures between -20°C and +45°C.

d) Pumps to start up under no load.

e) Bearings and other sliding parts shall be suitable for 10 000 hours operation at the continuous rated output of the pumps.

f) Where the drive shaft emerges from the pump casing, two separate seals, each being a continuous ring, shall be provided, the outer to exclude dirt and the inner to retain oil. The seals shall be compatible with the lubricants, hydraulic oils and flushing fluids likely to come into contact with them and shall run on non-corrodible material compatible with the respective shafts. A drain shall be provided between seals and the seals shall not be subject to seizure on the running face during long periods of idleness.

g) All internal nuts and bolts shall be locked with tab washers or by other similar means.

h) Pumps shall be coupled to drive machinery in such a way that no radial or axial loads are transmitted to the pump and such that the pump does not transmit radial or axial loads to the drive machinery.

i) Pumps shall be flange mounted to equipment in such a way that a pump may be removed and then replaced without the need for elaborate re-alignment procedures.

j) Pumps shall be of proven design.

k) All hydraulic pumps shall be tested in accordance with BS 4617 Class B.

l) Back-up hand operated pumps shall be supplied for use in case of power failure. The pump shall be sized to provide the design working pressure at an input of not more than 150 N.

m) The pump lever shall be mounted horizontally in a convenient position and at a comfortable height.

### 29.9.10 Filling Hydraulic Circuits

a) Each part of the hydraulic circuit shall be thoroughly cleaned before, and maintained clean during assembly.

b) After assembly the whole system shall be flushed using clean flushing oil at three (3) times the normal flow rate or an airmatic system until the Contractor has demonstrated that the system is as clean as may be expected when operating with the specified standard of filtration and new filters shall be fitted prior to filling the circuit with new hydraulic oil.

c) The circuit shall be designed in such a way that it may be filled or replenished only via the filters.

d) The system shall be filled with hydraulic oil of a 14/12 cleanliness rating.

### 29.9.11 Flexible Pressure Hose

a) All flexible pressure hose shall be long-life multi-spiral hose.

b) Flexible hose shall be installed into the pipework system at suitable locations to take up thermal movement and at points of differential movement between adjacent structures and/or equipment and where installation of rigid pipework might transmit unacceptable loads to a particular piece of equipment. The hose shall be installed in accordance with the manufacturer's recommendations, and shall be suitable for use with the fluid being transmitted at the operating vibration frequencies, pressures and temperatures.

c) The inner tube shall be seamless and shall be wound with alternate layers of spiral reinforcement in opposite directions, each separated by a layer of suitable synthetic rubber. The outer cover shall be resistant to abrasion and weathering in the environment of the installation.

d) Flexible hose end fittings shall be factory swaged into position and shall be manufactured from the same material as the pipe onto which it fits.

e) Flexible hoses shall be installed such that:

i) They are the correct length;

ii) Motion is in one plane and torsional stresses are avoided;

iii) Short radii and S-bends are avoided;

iv) Bend radii shall not be less than 1.2 times the minimum recommended in the appropriate British Standards;

v) They are securely supported and not subject to torsion or compression;

vi) They do not rub against any other hose, item or structure of any kind;

vii) They are protected against accidental damage and suitably restrained in areas where their failure might constitute a hazard;

viii) They are easily accessible for maintenance and inspection;

ix) Under normal working conditions that part of the hose adjacent to end fittings shall not flex for a distance equal to eight times the outside diameter of the hose; and

x) As far as is practicable they do not run horizontally.

### 29.9.12 Pressure Unloading Valves

a) At each power pack a pressure unloading valve shall be incorporated in the circuit so that pumps may circulate oil to tank at low pressure when the system demand is very small.

b) The valves shall have switching pressure differentials compatible with proper operation of the equipment in the hydraulic circuit and shall be of the pilot operated accumulator charging type.

### 29.9.13 Hydraulic Accumulators

a) Accumulators shall be of the nitrogen over oil bag type and shall be constructed to withstand not less than 5 times the system maximum working pressure.

b) Means shall be provided for safely relieving the nitrogen pressure for dismantling the accumulator and other parts of the circuit.

c) All circuits incorporating accumulators shall have facilities for bleeding at each high point.

d) Safety manifold blocks to be supplied with all accumulators.

### 29.9.14 Pressure Gauges

a) Pressure gauges for use in hydraulic systems shall be of the Bourdon tube type, shall be glycerine filled and shall generally comply with the requirements of BS 1780.

b) Gauge dials shall be not less than 100 mm diameter and shall have clearly marked divisions and figures in black on a white background.

c) Scale graduations shall be in units of MPa and the maximum scale readings shall be not more than 50% higher than the nominal working pressure of the system served.

d) No aluminium shall be used in the construction of the gauges; housing and bezels shall be of stainless steel. The internal components shall be of stainless steel, bronze or some other corrosion resistant material other than aluminium.

e) The gauges shall be mounted directly on a sub-plate or mounted flush on a panel.

f) Each pressure gauge shall be fitted with an isolation valve.

g) Pressure gauges shall be provided to measure the following:

- Pump delivery pressure;
- Cylinder feed pressure; and
- Cylinder return pressure.

h) The normal operating pressure shall be indicated with a red line on the gauges.

### 29.9.15 Hydraulic Cylinders

a) The hydraulic cylinders shall be of the single or double acting type as appropriate.

b) Horizontally mounted cylinders shall be of length sufficiently in excess of the maximum operating stroke so as to offer sufficient lateral rigidity to the piston when it is at normal full extension.

c) The rods shall be manufactured from stainless steel and hard chromed.

d) The Ra (Relative amplitude) on the rod and cylinder inner surface shall not exceed 0.2 µm.

e) Phosphor bronze guide bearings shall be used.

f) Rod sealing set shall be of the double acting lip seal type, capable of operating in submerged conditions to 10 metres.

g) A wiper seal shall be fitted to the cylinder cover.

h) The piston rod and piston shall comprise the following:

- A double acting piston manufactured from phosphor bronze or cast iron;
- Guide bearings of phosphor bronze;
- Pistons fitted with PU piston sealing sets of the double acting lip seal type; and
- Piston screwed to the rod and locked with a grub screw.

i) The top and bottom covers shall be attached by high tensile bolts or studs and special care shall be taken to ensure correct tensioning.

j) Where cylinders are connected by flexible pressure hose, the bottom connection shall be fitted with an automatic non-return valve of the pilot operated type to ensure against sudden loss of pressure within the cylinder in the event of a burst in the pressure hose.

k) The cylinders shall be provided with a cushioning arrangement at the extended end to the stroke.

l) Pivoted cylinders shall be provided with trunnions or clevises running on self-lubricating bearings.

m) All cylinders shall have bypass lines with isolator valves.

n) All isolator valves shall be equipped with position indication to prevent operation of the system when in the closed position.

o) All cylinders shall have isolating valves on the connecting pipe work and minimess test points on the inlet and outlet lines.

p) The cylinders shall be provided with pipe rupture protection.

### 29.9.16 Operating Pressures

In order to minimise leakages and wear on seals, etc., the operating pressures in hydraulic cylinders shall be limited to the following:

- Maximum working pressure: 18 MPa
- Test pressure: 25 MPa

## 29.10 CORROSION PROTECTION

### 29.10.1 General

The corrosion protection of all hydro-mechanical Plant shall be in accordance with Section 37 – Painting and Corrosion Protection and Section 28 – Mechanical General.

All components as per definition exposed to “Wet” conditions shall be considered as being exposed to anaerobic and aggressive water conditions.

| | | |
|---|---|---|
| Gate structure | : | Coating System 073 or 074 |
| Stop Logs | : | Coating System 061 |
| Gate (Slide) | : | Coating Systems 070 and 071 or 072 |
| Sealing Frames/Guides (wet) | : | Coating Systems 070 and 071 or 072 |
| Guides/Yoke (dry) | : | Coating System 070 |
| Operating Tandem and Spindles | : | Coating System 070 |
| Fasteners | : | Coating System 070 |
| Operator Housing | : | Coating System 050 or 051 for lining and 052 or 053 for Coating |

On completion of corrosion protection but before the items are dispatched to Site, the Contractor shall make provision for a final inspection. This shall include all necessary dry film thickness and pinhole tests. The Contractor shall further ensure that all quality control records are up to date and provided to the Engineer or Approved Inspection Authority (AIA). In addition, the elements shall be shop assembled to check the functionality of the components.

### 29.10.2 Propriety Items

Off-the-shelve components that are supplied as standard corrosion protected items e.g. gearboxes, actuators etc. will be accepted provided that they meet with the corrosion protection requirements of Section 37 – Painting and Corrosion Protection. In these instances, if the Specification cannot be adhered to, the Contractor shall submit full details of the equivalent coating systems for approval by the Engineer.

## 29.11 INSPECTION AND QUALITY CONTROL

Inspection and quality control shall be in accordance with Sections 28 and 38 for Mechanical General and Electrical General respectively.

All Plant items shall be assembled and tested for straightness, tolerance and functionality. The Contractor shall further allow the Inspectorate to satisfy himself that the Plant is cleared of all weld splatter, burrs and in general complies with the requirements as set out in Section 28 – Mechanical General. These tests and inspections shall be performed before the items are sent for corrosion protection.

## 29.12 OPERATION AND MAINTENANCE MANUALS

Submission of Operation and Maintenance Manuals shall be as required under Section 48 – Tests on Completion.

## 29.13 FACTORY ACCEPTANCE TEST AND PRE-COMMISSIONING

The Tests on Completion of mechanical Plant is generally covered by Section 48. This Section deals exclusively with the Factory Acceptance Testing (FAT) and Pre-Commissioning on Site of the Hydro-Mechanical Plant.

### 29.13.1 General

All Hydro-Mechanical Plant shall be carefully inspected and functionally tested at the factory before being dispatched to Site and Pre-commissioning of the Plant on Site after installation to prove that it is Ready for Commissioning (RFC).

#### 29.13.1.1 Factory Acceptance Test (FAT)

The Factory Acceptance Test (FAT) shall be carried out at the factory in the presence of and to the satisfaction of the Engineer to demonstrate that the Plant has passed its functional test and fully complies with the Specification. After passing the FAT the QCP can be signed off by the Engineer and/or AIA where after the Plant may be prepared for dispatch to Site.

#### 29.13.1.2 Pre-commissioning

Pre-commissioning shall be carried out by the Contractor after installation of the Plant on Site in the presence of and to the satisfaction of the Engineer to demonstrate that each part together with all its components functions correctly as a unit and that the Plant is Ready for Commissioning (RFC). The Engineer shall, at least 5 working days prior to pre-commissioning, have been provided with the most recently approved draft of:

- The appropriate Operation and Maintenance Manual;
- The complete Data Pack that includes signed-off Quality Control Plans (QCP's), material and test certificates, delivery notes etc.;
- The approved dry testing procedure, which shall show appropriate detail; and
- All electrical installations shall comply with the requirements of Section 39 – Electrical Plant and Installation.

a) Dry testing of the Plant (in liaison with the Engineer, Contractor and appropriate other Subcontractors where interfaces exist) shall include, but not necessarily be limited to tests that demonstrate that:

    - The seals are operating, mechanically, satisfactorily and according to the pre-compression recommended by the gate designer, that the clearances in the guides are adequate, and that the gates work correctly under all specified conditions that can be simulated in the absence of water head;

- The gates are clean and free of construction debris and spindles (stems) threads lubricated prior to operation of the gate; and
- The gates' hoist mechanisms are able to cycle the gate with ease on minimum of 1-1/2 cycles (open-close-open or vice versa) to ensure smooth operation and proof that the gates open fully as per design requirements.

b) All instruments, spares and appliances necessary for the complete testing including the supply of electricity shall be provided by the Contractor.

### 29.13.2 Test Certificates

Issuing of test certificates and reports on each specific test of Plant shall be in accordance with Clause 48.9.

## 29.14 APPLICABLE STANDARDS

The following Standards and Codes of Practice are relevant to in this Section:

**German Institute for Standardisation**

| | | |
|---|---|---|
| DIN 19074: Part 1 | : | Criteria of Design and Calculation |
| DIN 19704: Part 2 | : | Design and Manufacturing |
| DIN 19704: Part 3 | : | Electrical Equipment |

**South African National of Standards**

| | | |
|---|---|---|
| SANS 121 | : | Hot-dip galvanised coatings on fabricated iron and steel articles |
| SANS 142:2012 | : | Narrow Elastic Fabrics and Strip |
| SANS 1431 | : | Weldable Structural Steel |
| SANS 1700 | : | ISO metric precision hexagon-head bolts, screws and nuts (coarse thread medium fit series) |
| SANS 3581: 2008 | : | Welding Consumables for manual metal arc welding of stainless steel and heat resistant steels |
| SANS 10044 | : | Welding |
| SANS 10162-4:1997 | : | The Design of Cold-formed Stainless Steel Structural Members |
| SANS 50028-7: 2005 | : | Flat Products made of Stainless Steel for Pressure Purposes |

**American Water Works Association**

| | | |
|---|---|---|
| AWWA C513 | : | Open-channel, Fabricated-metal Slide Gates |

**American Petroleum Institute**

| | | |
|---|---|---|
| API 1104 | : | Standard for welding pipelines and related facilities |

**British Standards Institution**

| | | |
|---|---|---|
| BS 4677: 1984 | : | Arc Welding of Austenitic Stainless Steel Pipework for Carrying Fluids |

**South African Electrolytic Corrosion Committee**

Code of Practice No. SAECC/1

ANSI B31.3

ISO 3302

## 29.15 SPARE PARTS REQUIREMENTS

The Contractor shall list and price the spare parts considered to be necessary as required for the continued operation of all mechanical, electrical and electronic Plant based not only on a reliability analysis of the Plant, but also on the reliability and availability of local suppliers of spare parts. The lists shall also include all long lead maintenance items and special maintenance tools that will be required during the maintenance of the plant by the Contractor. The lists of additional critical spare parts must be submitted to the Engineer prior to achieving RFTO.

The total amount for spares derived from for each part of the Works shall be carried forward to the Bill of Quantities. A provisional sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.

## 29.16 MEASUREMENTS AND PAYMENT

The rates tendered under this Section shall not include for the general obligations, Contractor's Equipment and work deemed to be covered by the items provided in, Section 1 – General.

**29.001 Design and documentation** **Unit: lump sum (Sum)**

The rates tendered shall include for full compensation of all costs incurred in the preparation of the design and calculations, detail working drawings for all items, specifications, schematic diagrams, electrical drawings and wiring diagrams, layout drawings, operation and maintenance instructions, programmes of work (manufacture and on-site) and any other work as specified for the design of the complete installation. Payment will only be effected after the design and associated documentation has been approved by the Engineer.

Measurement and Payment for the preparation and submission of O&M Manuals shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

**29.002 Supply and deliver to Site** **Unit: number (No)**
**or: sets (Sets)**
**or: pairs (Pairs)**
**or: lump sum (Sum)**

The rates tendered shall include full compensation for the supply and delivery of the Plant to Site including supply of raw materials and bought-out items and associated operating Plant items (i.e. gearboxes and actuators; limit switches; cabling and electrical panels); fabrication, manufacture and assembly; quality assurance and quality control; inspection and Factory Acceptance Testing (including attendance on inspections and tests witnessed by the Engineer); type and routine tests; application of finishes (painting and corrosion protection); trial erection and dismantling; preparation and packing for transport; transport from place of manufacture to the Site; insurance, harbour dues etc., during transport; loading and unloading; storage under appropriate conditions from date of delivery until commencement of erection; and any other work as specified. Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

**29.003 Installation of Plant** **Unit: number (No)**
**or: sets (Sets)**
**or: pairs (Pairs)**
**or: lump sum (Sum)**

The rates tendered shall include for full compensation for the installation of the Plant on Site including the provision of all labour, transport, materials and Temporary Works necessary to install the complete Works; on-site quality assurance and quality control, inspection, testing (including attendance at tests witnessed by the Engineer); the installation of all auxiliary Plant items, actuators, limit switches, electrical panels, cabling etc.; necessary for the operation of the installation until taken over by the Employer; the putting into service of the complete installation of the Plant; and any other work as specified.

The rate shall also include for all pre-commissioning testing and the provision of equipment therefore including all disruptions to installation caused by such testing. Payment will be made per unit. Payment will only be effected after full compliance of the Plant items with this Section and associated documentation has been approved by the Engineer.

Measurement and Payment for Test on Completion shall be covered under Clause 48.11 of Section 48 – Tests on Completion and paid elsewhere.

**29.004 Spares** **Unit: Provisional sum (PS)**

The cost of spares, considered to be necessary by the Contractor other than spares required by the Employer, delivered to Site and handed over will be paid as a lump sum. A Spare Part Schedule by the Employer is available in Section 48 – Test on Completion and BoQ. The spares identified by the Contractor are to adhere to Clause 29.13 Spare Parts Requirements

The actual lump sum to be paid shall be based on the unit rates priced in the Bill of Quantity for the actual spares ordered and supplied and the Employer is entitled to purchase all, some or none of the items listed. A provisional sum will be allocated in the Bill of Quantity for the complete list of spare parts as listed by the Contractor.

The rate tendered shall provide for the manufacture, supply, delivery to Site and handing over of the spares ordered and shall include permanent packing for long term storage. The spares shall be manufactured at the same time as the installed items.