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

TENDER NO 054/2024/PMID/MCWAP2/RFB

PART C3.1
SPECIFICATION

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SECTION 36

FLOW METERS

36.1 SCOPE

This Specification Section covers the procurement, manufacture, delivery, installation, calibration, testing, commissioning, trial operation and maintenance of electromagnetic flow meters and ultrasonic flow meters for the measurement of raw water at ambient temperatures and at varying pressures.

Only products manufactured under full ISO 9001 certification shall be accepted.

It shall be read in conjunction with the modular suite of specification sections constituting the Specification in terms of this Contract.

36.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

36.2.1 Definitions

Except as indicated below the definitions given in SANS 10044 and SANS 719 shall apply:

a) **"Digital Indicator"** means an electronic indicator as specified.

b) "**Flow Meter System"** means the complete installation required to measure, display, totalise the flow in a pipeline at a point as specified inclusive of the surge protection, all cabling and telemetry interface.

c) **"Flow Sensor (Primary Element)"** means the section of the flow meter system comprising the pipe section, energising coils and measuring transducers that form an integral part of the pipeline.

d) **"Full scale"** means the accuracy or flow measurement error is expressed as a percentage of the maximum scale value of the calibration curve. (Legacy of the mechanical flow meters)

e) **"Reading"** means the accuracy or flow measurement error is expressed as a percentage of the actual value of the calibration curve.

f) **"Repeatability"** means producing the same outcome given the same conditions. In other words, a flow meter should produce the same readings when operated under the same variables and conditions. This, too, is expressed as a ± percentage.

g) **"Signal converter (Electronics)"** means the unit that energises the primary element and converts the flow signal to a numerical flow reading.

h) **"Surge Protection"** means any Plant used for the earthing, common bonding and surge diversion of any electrical surge as induced by the electrical supply system or lighting and weather related electrical surges.

i) **"Totalising Counter"** means an electro mechanical non-resetable counter as specified.

j) **"Transducers"** mean the units that transmit and receives a high frequency signal that enables the signal converter to determine the velocity of the water.

36.2.2 Abbreviations

DN	:	Nominal Diameter
PLC	:	Programmable Logic Controller
SCADA	:	Supervisory Control And Data Acquisition
EEPROM	:	Electrically Erasable Programmable Read-Only Memory

36.2.3 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

36.3 LOCATION

The location of the areas and relative position of the flow meter installations are indicated on the Drawings.

36.4 ELECTROMAGNETIC FLOW METERS

36.4.1 General

Electromagnetic flow meters shall be of a type suitable for application in raw, process and wastewater applications. They shall have high stability properties and shall require negligible maintenance over extended periods.

Notwithstanding any items of Plant as supplied standard with the flow meter systems the flow convertor consisting of indicator, totalizer, some surge protection and other Plant items shall be installed in a separate dedicated instrument panel that complies with the minimum requirements herein.

36.4.2 Operating Principle and Construction

The electromagnetic flow sensor shall consist of a length of smooth bore cylindrical pipe insert having an equal internal diameter to that of the pipeline into which it is to be inserted. There shall be no internal or moving parts in the flow. The flow measuring tube shall measure the flow bi-directionally. The pipe insert shall be non-magnetic and be lined throughout its bore with electric insulator material.

The flanges of the meter shall be drilled and tapped and shall be provided with stainless steel screws and washers and earthing pigtails for earth continuity across the meter onto the steel pipeline on both ends of the flow sensor. The earth pigtails shall be 500 mm in length with a cross-sectional area of no less than 35 mm^2 and shall consist of braided copper strap with soldered lugs on both ends. Stainless steel machine screws shall be at least 6 mm in diameter and four spare screws shall be provided with each flow sensor.

A homogenous magnetic field shall be generated across the pipe insert and the two diametrically opposing electrodes shall detect the voltage generated when liquid flows through the field. The measurements must be very reliable and independent of the flow profile going through the pipe.

This generated voltage shall be amplified by a remotely mounted flow convertor (amplifier and converter) to an electric signal suitable for receiving instruments such as indicators, recorders, integrators and controllers.

All electromagnetic flow meters shall consist of a separate detector head and flow convertor.

The protection class should conform to IP67 / NEMA 6.

For process water applications, the detector liner shall be made of Polypropylene material and shall be resistant to corrosion, aging and abrasion.

For wastewater applications, the detector liner shall be made of hard-wearing rubber material and shall be resistant to corrosion, aging and abrasion.

The flow sensor must be able to deal with process conditions where the solid content could reach as much as 25%.

The detector head electrodes and earthing discs to be supplied with the instrument shall be made of stainless-steel grade 316 or better for both process water and wastewater applications.

The electrodes shall be automatically cleaned and shall be maintenance free. Any build-up of fats and other debris on the electrodes shall not influence the operation of the instrument. In the selection of the instrument due cognisance shall be taken of the potential fatty nature of wastewater.

The flow meter shall conform to applicable standards like OIML R-49, BS EN ISO 4064, ISO 4064 and MI-001.

The output of the flow convertor shall be current, pulse and status output. The measuring range shall be auto-ranging (selectable).

The flow convertor shall be constructed of die-cast aluminium polyurethane-coated material.

The flow convertor shall be equipped with a large graphic display and be backlit with graphics. Configuration shall be direct or via an infrared interface for reading and writing of all parameters. The flow convertor shall have optical buttons for operator control without opening the housing. The flow convertor shall support MIMO (Multiple Input Multiple Output) technology. Additional requirements shall include the following:

- A pulse output non-resettable flow totalizer, totalizing in l/s, m^3/s, m^3/h, m^3 x 100, etc.;
- A current output flow rate indication in l/s, m^3/s, m^3/h, m^3 x 100, etc.; and
- A status output for alarm signalling to PLC / SCADA system when the internal verification process detects any “out-of-spec diagnostics”.

The flow convertor shall also have a galvanically isolated 4-20 mA output linear to flow that shall be connected to a PLC / SCADA system. This 4-20 mA output signal shall act as a “Re-transmit” function and shall not influence the operation and functionality of the flow meter system.

The flow convertor shall provide an integral diagnostic feature to monitor all internal circuitry and identity errors. The level of such errors shall be identified as fatal, permanent or warning and be

logged and stored. The minimum requirement is that the last 9 errors are to be stored in the memory of the flow convertor for a minimum period of 180 days.

A warning icon shall appear on the display when an error occurs. It shall be possible for the operator to view the error-code associated with the fault via a service menu on the display.

Access to the menu structure to effect changes to the settings shall be protected by a personal identification number (PIN) to prevent unauthorized tampering. Authorised personnel must however be allowed access to change the PIN if and when required.

In “Viewing Mode”, the operator must be able to scroll through the settings and readings without allowing him to change any of the settings, unless he knows the PIN.

The requirements for the current, pulse and status output shall conform to the following minimum specifications:

- The pulse output or frequency output shall be user selectable;
- Analogue output: 4 – 20 mA. The time constant shall be adjustable between 0.1 and 30 seconds;
- Frequency output: Frequency: 0-10 kHz, 50% duty cycle, adjustable 500 Hz, 1 kHz, 5 kHz, 10 kHz with adjustable time constant selectable between 0.1 to 30 seconds;
- Pulse output: User selectable negative / positive pulse with adjustable pulse widths from 64 µs to 4.2 seconds with selectable volume unit / pulse; and
- Status output: Change-over type 42 VAC, 2 A or 24 V DC, 1 A selectable as error or control or for low or high flow limit switch with adjustable hysteresis.

The flow convertor shall have a variable span facility; with automatic zero control and a signal hold facility.

The flow convertor shall preferably operate on a pulsed DC field or other means to reduce power consumed and prevent electrode polarization and zero drift. The flow convertor shall be capable of non-full pipe detection.

36.4.3 Installation

Where electromagnetic instruments are required, a removable pipe section of adequate length shall be provided by the Contractor. This pipe section shall be flanged on one end and shall be supplied with a flexible coupling (Viking-Johnson, Klamflex or similar approved by the Engineer) on the other end.

The Contractor will be required to shorten the pipe insert to accommodate this flow meter head. Before ordering the detector head, the Contractor shall ascertain the flange details of the pipe supplied so that the detector flanges and pipe work flanges match.

The lining of the flow meter head shall not be used as a gasket. Suitable gaskets shall be provided and installed between the flow meter head, earthing rings and adjacent pipe work.

A suitable local earth shall be provided by means of 1, 8 m copper earthing electrodes. Sufficient electrodes shall be provided to obtain an earth resistance of less than 1 ohm.

The signal cable must be able to carry the flow signal to a maximum distance of 500 metres without the need for additional signal repeaters or conditioners.

The isolation spark gaps to be installed on the pipeline in the manhole shall conform to the Drawings and Section 28 – Mechanical General. These isolation spark gaps shall be connected via the earth bars onto the earth point as supplied by the pipeline Contractor.

A removable EEPROM with flow sensor data stored in the EEPROM shall be provided with the flow sensor and shall contain the following:

- Serial Number;
- Sensor Size; and
- Calibration Factor.

Between the flow sensor and flow convertors, there shall be two separate lengths of 3-core, multi-strand, 1.0 mm^2 individually insulated with an overall braided screened instrumentation cable.

The instrument cabinet fitted with the flow convertor, electrical surge protection and related Plant items shall be installed against the wall inside the flow meter chamber.

The installation shall include for all required interconnections and sundries between the flow sensor and flow convertor.

The flow meter must be installed on a straight and unobstructed length of pipe. The length of pipe upstream and downstream from the flow meter shall conform to the following minimum straight and unobstructed lengths required before any bend, Tee-section or obstruction occurs:

- Upstream of flow meter – A length greater or equal to 10 times the diameter of the pipe (10ND<L<20ND); and
- Downstream of flow meter – A length greater or equal to 5 times the diameter of the pipe (5ND<L<10ND).

The flow meter flanges shall be suitable for the rating of the operating pressure and related pipe work at the proposed location as indicated on the Drawings. The instrument shall be able to measure bidirectional flow.

36.4.4 Type Testing

Type tests shall have been performed on Plant to be supplied under this Contract. Type test certificates to be submitted with tender documents. The Testing authority shall be traceable and internationally recognised.

36.4.5 Flow Meter System Assembly

The flow meter system contractor shall be available for supervision and technical assistance as and when required.

The termination of the cable work and the commissioning shall be included in the flow meter system contract and shall be performed by the flow meter system supplier and be witnessed by the Engineer or his representative.

Instrument panel fitted with the flow meter, digital indicator, totalising counter, electrical surge protection as applicable and related Plant as specified are installed at a point up to 150 m removed from the flow sensor.

Flow meters are installed in the pipe in the flow meter chamber at each site as applicable.

Isolating spark gaps, type EXFS to be installed on the pipeline in the manhole and to be connected via the earth bars onto the earth point as supplied by the pipeline contractor. Others shall supply all cable and related Plant.

36.4.6 Calibration Certificate

A manufacturer's calibration certificate, proving that calibration was performed at least twice at two calibration points, shall be supplied with each flow sensor. Operation and Maintenance Manuals. Submission of O&M Manuals shall be as required under Clause 48.9.

36.4.7 Operation and Maintenance Manuals

Submission of O&M Manuals shall be as required under Clause 48.9.

36.4.8 Marking and Labels

Each primary element shall be clearly marked with the following information on the body of the primary element:

- Serial Number;
- Year of Manufacture;
- Size;
- Supplier's name;
- Pressure rating; and
- Maximum Velocity.

This information shall be engraved on a non-detachable metal disk with lettering at least 10 mm high and 5 mm wide.

For marking and labelling of the instrument and electrical cabinets or kiosks, refer to Section 39 – Electrical - Plant and Installation.

36.4.9 Training

For all information regarding training of personnel on the MCWAP-2, refer to Section 48 – Tests on Completion.

36.4.10 Commissioning

Only instruments that can be programmed with ease and without specialized knowledge or Plant shall be considered. It shall further be performed without the use of additional external equipment such as laptops or desktop computers.

The Contractor shall in advance inform the Engineer of how commissioning will be done on site and what is required to ensure re-calibration of the flow convertor and sensor in the case of replacement on site of any of the items.

All other variables are to be programmed into the flow convertor using a user-friendly cascading menu structure.

In the event of a faulty or missing EEPROM or any other memory device, the menu structure shall allow for the manual programming of calibration information or data.

36.4.11 Verification

The flow meter system shall consist of an internal verification system between the flow sensor and flow convertor. The process shall entail application and process diagnostics as well as accuracy and linearity tests (out-of-spec diagnostics) in addition to the usual diagnostic checks. The application problems that are to be checked are the following:

- Gas bubbles;
- Electrode corrosion;
- Deposits on electrodes;
- Short-circuit;
- Low conductivity;
- Partial filling of measuring tube;
- Liner damage;
- External magnetic fields; and
- Disrupted flow profile.

The internal verification process shall send through an alarm condition to the Control system using the status output if any of the above-mentioned is not within specification.

36.4.12 Guarantee

For all information regarding the guarantees pertaining to electronic Plant and instrumentation of the MCWAP-2, refer to Section 48 – Tests on Completion.

36.4.13 Reducer Pieces

Reducer pieces shall be manufactured to comply with the minimum requirements for the flow sensor.

Reducer pieces shall be manufactured from the same type and quality steel plate as would the relevant straight pipe for the same duty. Reducer pieces shall not have more than two longitudinal weld seams and the tapered portion shall be at least five times the length of the tapering difference.

Tapered sections shall have a maximum angle of divergence of 10^{o}.

36.4.14 Flanges and Gaskets

For all specifications and standards regarding the flanges and gaskets to be used for MCWAP-2, refer to Section 28 – Mechanical General.

36.4.15 Insulating Flanges

Insulating flanges and materials shall be arranged as set out in Code of Practise No. SAECC/1 or SANS 15589-2.

For all specifications and standards regarding the insulating flanges required for MCWAP-2, refer to Section 28 – Mechanical General and Section 34 AC Mitigation and Cathodic Protection.

36.4.16 Instrument Cabinet

Instrument cabinets are required to house the flow convertor, indicators / integrators, surge protection, etc. of each flow meter system. The instrument cabinets shall have the following dimensions:

- Height – 645 mm;
- Width – 435 mm; and
- Depth – 250 mm.

The minimum IP rating of these instrument cabinets shall be IP66. The panels and doors of these instrument cabinets shall be constructed from reinforced glass fibre / impregnated polyester. The instrument cabinets shall be wall mounted with 4 stainless steel wall mounting lugs giving a space of at least 10 mm between the enclosure and the wall.

The instrument cabinets shall be fitted with a painted metal chassis of at least 2.5 mm thick. The instrument cabinet shall be fitted with a glazed door that allows viewing of the indicators and integrators. The window of the door shall be at least equal to 50% of the total area of the door part of the enclosure.

The door shall be removable and have concealed hinges and captive stainless-steel hinge pins. The door shall have an in situ moulded polyurethane sealing gasket fitted to a groove and two closure points that are situated outside of the sealed area. It shall be fitted with at least one cylindrical barrel type lock and two keys shall be supplied with each cabinet. The mechanical resistance of the enclosure with the glazed door shall comply with IK08 (5 Joules to standards EN50102).

The instrument cabinet shall also be fitted with a full-size internal door for mounting of the totalizers and integrators. The internal door shall be reversible. Each instrument cabinet shall be fitted with a M10 brass bolt, two brass nuts and two rubber washers that will act as an equi-potential bar. All surge protection in the enclosure shall be grounded onto this bolt.

36.4.17 Cathodic Protection

All pipes shall be cathodic protected, and the Contractor shall ensure that all requirements for the flow meter systems as installed in cathodic protected pipelines are met. All special modifications, excluding insulating flanges, common and cross bonding and other related CP requirements at the flow meter system, shall be included in the rate for supplying the meter.

For all installation requirements, specifications and standards regarding cathodic protection for the MCWAP-2 refer to Section 34 – AC Mitigation and Cathodic Protection.

36.4.18 Electrical Surge Protection

The Contractor shall, apart from his own defined requirements, provide for the supply, installation and commissioning of the following surge protection that shall be equal or similar to that as supplied by Surgetek:

(a) Single Pole for Zone 0b – 1, Class B

One for each flow meter system, in accordance with E DIN VDE 0675-6:1989-11 and –6/A1:1996-03 fitted with zinc oxide varistor, Dehn guard.

- Rated voltage 275VAC;
- Max Discharge current (8/20): 40 kA;
- Response time < 25 ns; and
- 35 mm din rail mounting.

(b) Surge Arrester for Tt Systems, for Zone 0b – 1, Class C

One for each flow meter system, in accordance with E DIN VDE 0675-6:1989-11, –6/A1: 1996-03 and –6/A2:1996-10 as spark gap type arrester, Dehn gap.

- Rated voltage 255 V/ 50 Hz;
- Nominal discharge current (8/20): 20 kA.;
- Response time < 100 ns;
- Voltage protection level: 1500 V; and
- 35 mm din rail mounting.

(c) Surge Protection Device Class D

One for each flow meter system, a two-pole surge protection device with supervisory and disconnection device. Class D device in accordance with E DIN VDE 0675-6:1989-11 and –6/a1:1996-03, Dehn rail.

- Nominal voltage 230VAC;
- Nominal Current 16 A;
- Nominal Discharge current (8/20): 3 or 5 kA.;
- Response time<25 or 100 ns; and
- Protection level <1.5 kV.

(d) 35 mm Din Rail Mounted Modular Surge Arrester

Four for each flow meter system, a two pole, universal current / surge arrester in modular terminal block system. Device in accordance with IEC 61312-1, Blitsductor.

- Nominal voltage 24 VAC/DC;
- Nominal Current 6 A;

- Nominal Discharge current (8/20): 3 or 5 kA;
- Response time <25 or 100 ns;
- Protection level <1.5 kV; and
- 35 mm din rail mounting.

(e) Isolating Spark Gaps

Two for each flow meter system, isolating spark gaps of the Type ExFS, Imp 100 kA (10/350).

- Ac spark over voltage < 2.5 kV;
- 100% standard lightning spark over voltage (1.2/50);
- Enclosure steel with external weather-proof plastic coating;
- Cable length 300 mm; and
- Complete with connection bracket Type IF 1.

(f) Earth Bars

For each flow meter system two (2) Earth bars with a Cross section not less than 90 mm^2 fitted with two terminals for 30 mm copper flat bar, two terminals for 16-95 mm^2 conductors and four terminals for less than 16 mm^2 conductors. Terminal bar to be at least 190 mm long with two bar holders and a plastic cover.

(g) Copper Cable

50 metres of stranded copper cable for connection of the pipeline spark gaps to the earth mats and the instrument cabinet equi-potential earth point to earth mat. Cross sectional area not less than 70 mm^2. Complete with appropriately sized crimped lugs. They must be secured at intervals not more than 500 mm apart.

36.4.19 Signal Converter (Electronics)

36.4.19.1 Enclosure

The signal converter will be housed in an IP67 enclosure with a membrane protected keypad and user configurable, 3-line LCD display. The signal converter shall be mounted in a glass fibre reinforced / impregnated polyester cabinet as specified in these documents.

36.4.19.2 Measuring Ranges

The measuring range shall be auto-ranging (selectable) between 0-0.25 m/s and 0-10 m/s.

The signal converter shall be capable of being used for flow sensor sizes from DN6 to DN1800.

36.4.19.3 Signal Outputs

All outputs shall be galvanically isolated.

The signal converter shall provide multiple outputs (MIMO technology). These shall include the following:

a) Analogue output: 0 to 20mA or 4 - 20mA, user selectable. Load $<800\Omega$. Time constant adjustable 0.1 to 30 seconds.

b) Pulse output or frequency output, user selectable:

- Frequency output mode: Frequency: 0-10 kHz, 50 % duty cycle, adjustable 500Hz, 1kHz, 5kHz, 10kHz, with adjustable time constant selectable between 0.1 to 30 seconds.
- Pulse output mode: User selectable negative / positive pulse with (17) adjustable pulse widths from 64μs to 4.2 seconds. With selectable volume unit / pulse.
- Relay output: Change-over type 42 VAC, 2 A or 24 VDC, 1 A selectable as error or control or for low or high flow limit switch with adjustable hysteresis.

Communication interface options shall include the following for integration into third party systems:

a) 4 – 20 mA;

b) Modbus TCP/IP;

c) Foundation Fieldbus;

d) PROFIBUS DP;

e) PROFIBUS PA; and

f) PROFINET IO.

Shall include custody transfer approvals like OIML R 49 and R 117-1, MI-001, MI-004 and MI-005.

Under the PROFINET IO option, real time Ethernet communication shall be connected to the IoT (Internet of Things). PROFINET IO shall be connected to PLC Units via network switches using either point to point network topology, ring network topology or the star network topology.

36.4.19.4 Counters

Two independent, integral counters shall be capable of totalising flow either as forward flow, reverse flow or as nett flow.

36.4.19.5 Zero point Adjustment

Zero point adjustment must be automatic.

36.4.19.6 Non-Full Pipe Detection

The signal converter shall be capable of non-full pipe detection.

36.4.19.7 Display

The flow convertor shall be equipped with a large graphic display and be backlit with graphics. Configuration shall be direct or via an infrared interface for reading and writing of all parameters.

The flow convertor shall have optical buttons for operator control without opening the housing. The flow convertor shall support MIMO (Multiple Input Multiple Output) technology.

The display parameters shall be user selectable to display the units of flow and totalisation such as l/s, m^3/s, m^3/h, m^3, m^3x100 etc.

36.4.19.8 Signal Processing

The signal processing must be microprocessor based and be capable of continuously monitoring the electronics and compensating for temperature drift via a self-monitoring circuit. The analogue to digital conversion shall be processed by a 23 bit ASIC.

The turn down ratio shall be at least 3000:1.

A high input impedance shall be provided of >10 to 14Ω.

36.4.19.9 Commissioning

Only instruments that can be programmed with ease and without specialised knowledge or Plant shall be considered. It shall further be performed without the use of additional external equipment such as lap top computers.

The tenderer shall state in the space provided further on for that purpose how commissioning will be done on site and what is required to ensure re-calibration of the flow converter and sensor in the case of replacement on site of any of the items.

All other variables are to be programmed into the signal converter via a membrane protected keypad on the signal converter and a user-friendly cascading menu structure.

In the event of a faulty or a missing EEPROM or other memory device, the menu structure shall allow for the manual programming of calibration information. All variables shall be programmable into the signal converter via a membrane protected keypad on the signal converter.

36.4.19.10 Power Supply

Only 220 VAC shall be provided for on site. Any other power requirements have to be provided for by the flow meter system contractor.

36.4.19.11 Diagnostics

The signal converter shall provide an integral diagnostic feature to monitor all internal circuitry and identify errors.

The level of any such errors shall be identified as fatal, permanent or warning and be logged and stored. At least the last 9 errors to be stored in the memory of the flow converter for a minimum of 180 days. A warning icon shall appear on the display when an error occurs. It shall be possible for the operator to view the error-code associated with the fault via a service menu on the display.

36.4.19.12 PIN Protection

Access to the menu structure to effect changes to the settings will be protected by a personal identification number (PIN) to prevent unauthorised tampering. Authorised personnel must however be allowed access to change the PIN if and when required.

In “view-mode”, the operator must be able to scroll through the settings and readings without allowing him to change any of the settings, unless he knows the PIN.

36.4.19.13 Surge and Lightning Protection

Enhanced lightning and surge protection modules will be required. Each installation will be equipped with surge protection for the main power supply as well as the 2 lengths of cable between the flow sensor and the signal converter. Additional earthing and surge protection is required as specified later in these tender documents.

36.4.19.14 Cable between Sensor and Converter

Two separate lengths of cable shall be supplied for each flow meter system. The cable shall be at least 3 core, multi-strand, 0,5 mm², individually insulated, with and overall braided screened, instrumentation cable.

36.4.20 Flow Sensor (Primary Element)

36.4.20.1 Installation

Expected distance between transducers and signal converter can be up to 150 meters.

36.4.20.2 Measuring System

The flow sensor shall utilise pulsed DC measuring technology.

User selectable D.C. excitation frequency of 1 9/16 Hz, 3 1/8 Hz, 6 ¼ Hz, 12,5 Hz, or 25 Hz shall be utilised.

36.4.20.3 Sensor Tube

The flow sensor measuring tube shall be made from stainless steel AISI 304 grade Stainless Steel.

36.4.20.4 Sensor Tube Liner

The flow sensor tube shall be lined with Neoprene lining and be capable of operating under the following conditions:

- Temperature rating : -10° C to +95° C
- Pressure rating : 1 kPa to 4000 kPa (Absolute)

36.4.20.5 Earthing Electrodes

The flow meter shall be provided with both sensing and earthing electrodes built into the flow meter, eliminating the need for earthing rings. The material of the electrodes must be 316Ti stainless steel. The electrodes shall be the non-removable types.

The flanges of the meter shall be drilled and tapped and shall be provided with stainless steel screws and washers and earthing pigtails for earth continuity across the meter onto the steel pipeline on both ends of the flow sensor. The earth pigtails shall be 500 mm in length with a cross sectional area of at least 35 mm^2 and shall consist of braided copper strap with soldered lugs on both ends. Stainless steel machine screws shall be at least 6 mm in diameter and four spare screws shall be provided with each flow sensor.

36.4.20.6 Housing and Flange material

The housing and flange material shall be manufactured from low-grade carbon steel complying with the requirements of Clause 28.16 in Section 28: Mechanical General. The corrosion protection shall be as per Clause 37.10.8 of Section 37 - Painting and Corrosion Protection.

36.4.20.7 Enclosure Protection

Rating shall be IP 68 to IEC 529 (10 m w.g.) after final testing.

Terminal boxes on the flow meters will be encapsulated in a special resin after final installation and commissioning. Only resin, which does not solidify over time, and which can be removed from the terminal box with relative ease at a later stage, will be acceptable. IP68 submersible kits must be provided for to protect the sensors against moisture and flooding and shall be applied by the flow meter supplier.

36.4.20.8 Maximum Pressure

The maximum test pressure shall be 1.5 x PN.

36.4.20.9 Mechanical Test Criteria

The flow meter shall be capable of withstanding the following criteria:

- Load 18-1000 Hz random, 3.17G RMS, in all directions to IEC 68-2-36.

36.4.20.10 Flange Specifications

Flange rating of flow meters shall be as indicated on the drawings and comply with the requirements of Clause 28.15 in Section 28 - Mechanical General.

36.4.20.11 Calibration Certificate

A manufacturer’s calibration certificate, proving that calibration was performed at least twice at two calibration points, shall be supplied with each flow sensor.

36.4.20.12 EEPROM Backup

A removable EEPROM with flow sensor data stored in the EEPROM, shall be provided with the flow sensor and shall contain at least the following data:

- Serial number;
- Sensor size; and
- Calibration factor.

The EEPROM shall have a memory capacity to store the operational data for 1 month.

36.4.20.13 Terminal Box

The terminal box shall be manufactured from glass-fibre reinforced polyamide fitted with a gasketed lid that is held in place with at least two stainless steel securing bolts.

36.4.21 Totalising Counter

One separate totalising counter shall be supplied for each flow meter system irrespective of any functionality provided for in the flow converter. Each counter to be fitted into an IP 66 enclosure as specified in such a way that the reading is clearly visible with space available for the labelling and surge protection as specified.

Size of cable to be used for the transfer of the signal from the flow meter unit to the digital indicator shall not be less than 1 mm^2.

One separate non-resetable electro mechanical totalising counter is to be supplied for each flow meter.

Number of digits shall be 8 (eight) and height of digits to be at least 4 mm.

The unit to be mounted in a separate, dedicated frame with Shock-stability to 600 m/s^2 and shall comply with IEC 068-2-27.

Vibro-stability shall be 50 m/s^2 and to comply with IEC 068-2-6.

Operating temperature -10 to +60 0 C.

Minimum Pulse length of the DC counter to be 20 ms and the counting frequency shall be 25 Hz. For the Ac counter the pulse length shall be 50 ms and the counting frequency shall be 10 Hz. Power consumption shall be 2.5 W/VA for DC and 2.75 W/VA for AC.

Supply voltage tolerance $\pm$ 10 %.

36.4.22 Digital Indicators

One separate digital indicator shall be supplied for each flow meter system irrespective of any functionality provided for in the flow converter. Each indicator to be fitted into an IP 66 enclosure as specified in such a way that the reading is clearly visible with space available for the labelling and surge protection as specified.

The indicated flow to be a direct function of the isolated 4 to 20 milli amp output.

The digital display shall be a 5-digit, 0.56” (14.2 mm) High Red L E D, giving a maximum display of 99999.

The decimal point shall be selectable and a flashing display shall be given during totaliser overflow.

It shall be constructed in such a way that it can be programmed to the required flow and by means of a selector button, display the accumulated quantity of water released.

The front bezel shall meet NEMA 4/IP65 requirements.

A differentiated indication shall be given for an input display overload, an input display under load (negative overload) and for input display out of range.

The indicator / integrator shall have a lock-out facility to limit operator entry to the programmable settings and totaliser.

The totaliser shall have a programmable time base with a scale factor of 0.001 to 100.0 and a low-end cut-out.

The indicator / integrator shall be powered by 230 V AC at 50 Hz.

It shall be fitted with a key switch in order to reset the integrator on totaliser overflow.

36.4.23 Instrument Cabinet

A total of nine instrument panels are required to house the signal converter, indicator, mechanical integrator, surge protection, etc. of each flow meter system.

The instrument panels shall have minimum dimensions 645(H) x 435 (W) x 250 (D) and shall be equal or similar to a Sarel cabinet of the Thalassa type. The rated minimum degree of ingress protection to comply with IP66.

The instrument panel and all doors to be constructed from glass fibre reinforced / impregnated polyester.

The units shall be wall mounted with 4 stainless steel wall mounting lugs giving a space of at least 10 mm between the enclosure and the wall.

Shall be fitted with a painted metal chassis of at least 2,5 mm thick.

The instrument panel to be fitted with a glazed door that allows sights of the indicator/s and integrator/s. The window to be at least 50% of the front area. The external door shall be removable and have concealed hinges and captive, stainless steel hinge pins. The external door shall have an in situ moulded polyurethane sealing gasket fitted to a groove and two closure points that is situated outside the sealed area. It shall be fitted with at least one cylindrical barrel type lock and two keys shall be supplied for this lock. Resistance of the enclosure with the glazed door to comply with IK 08 (5 Joules) to EN 50 102.

It shall also be fitted with a full size internal door for mounting of the totalisers and integrators. The internal door shall be reversible.

Each enclosure to be fitted with a M10 brass bolt, two brass nuts and two rubber washers that will act as an equipotential bar. All surge protection in the enclosure to be grounded onto this bolt.

36.4.24 Accuracy

The accuracy of the meter shall be guaranteed equal or better than:

- 100.0 ± 0.5 % of full scale; and
- The repeatability of the meter shall be better than 0.1% of full-scale deflection and the linearity of the meter shall be better than 0.05% of full-scale deflection.

36.4.25 Maintenance

The meter shall be maintenance free.

36.4.26 Power Requirements

The meter shall be fed from 24 VDC supply. The meter shall have battery back-up capable of providing 24 VDC power to the meter for a minimum period of 72 hours in case of a power failure and at least a two year operating life.

The batteries shall be of the deep cycle rechargeable type of batteries.

36.4.27 Storage, Handling and Transport

Flow meters shall be protected against damage at all stages from manufacture to delivery. Particular care shall be taken to protect the ends of all flow meters against denting. Flow meters shall be transported and stacked in a manner such as to prevent deformation. Dents causing a protrusion into the interior of a pipe or into the outer cover of the coils shall result in the flow meter being rejected.

Satisfactory temporary end covers shall be provided for the protection of primary elements to prevent damage to the internal lining during transportation and during handling on Site.

Primary elements shall be so transported, stored and handled that the primary elements are not stressed at any time and fittings are not damaged in any way. Any defective equipment shall be removed from the Site at no cost to the Employer.

The primary elements shall at all times be handled with approved equipment, employing stout, wide canvas or rubber-covered slings and wide padded skids designed to prevent damage to the exterior coating. The slings shall be at least 300 mm wide for pipes up to DN 600, 500 mm wide for pipes of DN 700 and up to DN 1200 and 800 mm wide for pipes of DN 1400 and larger or as approved.

Bare cables, chains, hooks, metal bars, or narrow skids shall not be allowed to come in contact with either the exterior coating or the interior lining of the primary element.

The Contractor shall be responsible for the transport of all flow meter equipment to Site, off-loading and storage on Site, all in accordance with the Specifications.

36.4.28 Information and Drawings to be submitted

Sufficient information shall be supplied with the tender giving enough information to make a proper assessment of the flow meter systems offered. Information supplied shall include (but not necessarily be limited to):

a) Technical details of the flow meter systems;

b) Principle of operation;

c) Installation requirements;

d) Earthing and surge protection detail including the name of the supplier of the surge suppression units and technical details of units tendered;

e) Supplier detail and technical detail for the instrument cabinet, totaliser and digital display units; and

f) Effect of cathodic protection on the flow meter system and special requirements.

36.5 BATTERY OPERATED ELECTROMAGNETIC FLOW METERS

36.5.1 General

Flow meters shall be of a type suitable for application in raw water applications. They shall have high stability properties and shall require negligible maintenance over extended periods.

36.5.2 Operating Principle and Construction

The electromagnetic flow sensor shall consist of a length of smooth bore cylindrical pipe insert having an equal internal diameter to that of the pipeline into which it is to be inserted. There shall be no internal or moving parts in the flow. The flow measuring tube shall measure the flow bi-directionally. The pipe insert shall be non-magnetic and be lined throughout its bore with electric insulator material.

A homogenous magnetic field shall be generated across the pipe insert and the two diametrically opposing electrodes shall detect the voltage generated when liquid flows through the field. The measurements must be very reliable and independent of the flow profile going through the pipe.

This generated voltage shall be amplified by a remotely mounted flow convertor (amplifier and converter) to an electric signal suitable for receiving instruments such as indicators, recorders, integrators and controllers.

All electromagnetic flow meters shall consist of a separate detector head and flow convertor. The protection class should conform to IP68 / NEMA 6P.

For process water applications, the detector liner shall be made of Polypropylene material and shall be resistant to corrosion, aging and abrasion.

For wastewater applications, the detector liner shall be made of hard-wearing rubber material and shall be resistant to corrosion, aging and abrasion.

The flow sensor must be able to deal with process conditions where the solid content could reach as much as 25%.

The detector head electrodes and earthing discs to be supplied with the instrument shall be made of stainless-steel grade 316 or better for both process water and wastewater applications.

The electrodes shall be automatically cleaned and shall be maintenance free. Any build-up of fats and other debris on the electrodes shall not influence the operation of the instrument.

The flow meter shall conform to applicable standards like OIML R-49, BS EN ISO 4064, ISO 4064 and MI-001.

The flow convertor shall be constructed of die-cast aluminium polyurethane-coated material.

The output of the flow convertor shall be pulse output.

The flow convertor shall be equipped with a high-contrast, high-resolution display, a non-resettable flow totalizer and an isolated pulsed output for remote flow totalizing. The flow convertor shall also have a data logger option for remote totalizing.

The data logger shall be able to store 1 reading per minute for a period of no less than 1 month. The data logger shall be battery powered and have a lifespan of not less than 5 years. The data logger shall have an IP rating of IP68.

The data logger shall work on a wireless communication protocol like IEC 61107 which utilizes short range infrared energy waves or better. The data from the data logger shall be accessible through a wireless connection to a Notebook or PC for analysis.

No proprietary software shall be needed to analyse the data. The data shall be easily exported into spreadsheets or billing systems.

Other options shall include RS485 Modbus RTU communication and a GPRS / data logger for data transfer.

The flow convertor shall be able to work with different energy sources. These shall include:

a) An internal lithium battery option as standard with a minimum battery lifetime of 10 years;

b) An external battery pack option to extend beyond the 10 years lifetime;

c) An AC mains supply and;

d) A DC power option using green energy like solar or wind power both having a battery backup.

36.5.3 Installation

Where electromagnetic instruments are required, a removable pipe section of adequate length shall be provided by the Contractor. This pipe section shall be flanged on one end and shall be supplied with a flexible coupling (Viking-Johnson, Klamflex or similar approved by the Engineer) on the other end.

The Contractor will be required to shorten the pipe insert to accommodate this flow meter head. Before ordering the detector head, the Contractor shall ascertain the flange details of the pipe supplied so that the detector flanges and pipe work flanges match.

The lining of the flow meter head shall not be used as a gasket. Suitable gaskets shall be provided and installed between the flow meter head, earthing rings and adjacent pipe work.

A suitable local earth shall be provided by means of 1,8 m copper earthing electrodes. Sufficient electrodes shall be provided to obtain an earth resistance of less than 1 ohm.

The instrument installation shall include for all interconnections and sundry requirements between sensor and control / amplifier unit.

The flow meter must be installed on a straight and unobstructed length of pipe. The length of pipe upstream and downstream from the flow meter shall conform to the following minimum straight and unobstructed lengths required before any bend or obstruction occurs:

- Upstream of flow meter – A length greater or equal to 5 times the diameter of the pipe (5ND<L<10ND); and
- Downstream of flow meter – A length greater or equal to 3 times the diameter of the pipe (3ND<L<5ND).

The flow meter flanges shall be suitable for the rating of the operating pressure and related pipe work at the proposed location as indicated on the Drawings. The instrument shall be able to measure bi-directional flow.

36.5.4 Accuracy

The accuracy of the meter shall be guaranteed equal or better than:

- 100.0 $\pm$ 0.5 % of full scale.

36.5.5 Maintenance

The meter shall be maintenance free.

36.6 ULTRASONIC CLAMP ON FLOW METERS

36.6.1 General

Ultrasonic clamp-on flow meters shall be microprocessor based; non-contact flow meters and shall be able to be programmed to read liquid flow accurately passing through any pipe.

The Ultrasonic clamp-on flow meters shall be of the dual-sensor type.

The meter shall have a low signal-to-noise ratio and shall be able to damp acoustic signals.

The instrument shall be able to measure bidirectional flow.

36.6.2 Operating Principle

A burst of ultrasonic pulses is transmitted from a transducer, which is not in contact with the water flow being measured. The transmitter (sensor A) transmits pulses through the water and is received by the receiver (sensor B) situated opposite.

The time delay between the transmitted and received signal is proportional to the flow between the transmitter / receiver. The transmission time of the signal is fixed. The medium is variable. From this relationship, the flow can be calculated.

To compensate for the temperature dependence of the ultrasonic signal, the air temperature shall be measured at the transducer and shall be taken into consideration when the flow difference is calculated between transmitter and medium.

The flow sensor shall be able to deal with process conditions with a solid content of 3% maximum.

36.6.3 Construction

The ultrasonic flow meter shall be a robust industrial clamp-on meter, and shall consist of two parts, namely a clamp-on flow sensor and a flow convertor.

The protection class shall conform to IP67 / NEMA 6.

The measuring functions shall show at least the actual instantaneous rate of flow as well as the totalized volume of flow.

The meter shall be corrosion protected as well as be resistant to UV radiation.

The flow convertor shall be constructed of die-cast aluminium polyurethane coated material.

All outputs shall be galvanically isolated.

The signal converter shall provide multiple outputs (MIMO technology).

Communication interface options shall include the following for integration into third party systems:

a) 4 – 20 mA

b) Modbus TCP/IP;

c) Foundation Fieldbus;

d) PROFIBUS DP;

e) PROFIBUS PA; and

f) PROFINET IO.

It shall include custody transfer approvals like OIML R 49 and R 117-1, MI-001, MI-004 and MI-005.

Under the PROFINET IO option, real time Ethernet communication shall be connected to the IoT (Internet of Things). PROFINET IO shall be connected to PLC Units via network switches using either point to point network topology, ring network topology or the star network topology.

The output of the flow convertor shall be current, pulse and status output. The output shall be galvanically isolated.

The flow convertor shall be equipped with a large graphic display and be backlit with graphics. Configuration shall be direct or via an infrared interface for reading and writing of all parameters. The flow convertor shall have optical buttons for operator control without opening the housing. The flow convertor shall support MIMO (Multiple Input Multiple Output) technology. The flow convertor shall display the following:

- A pulse output non-resettable flow totalizer, totalizing in l/s, m^3/s, m^3/h, m^3 x 100, etc.;
- A current output flow rate indication in l/s, m^3/s, m^3/h, m^3 x 100, etc.; and
- A status output for alarm signalling to Control System.

36.6.4 Installation

The ultrasonic transducer shall be supplied complete with mounting bracket and frame. The mounting frame shall be rigid and made from stainless steel. The transducer shall be mounted in such a way that it is free from all handrails, walkways, etc. Passing traffic and the operation of other machines in the vicinity of the transducer shall have no influence on the transducer.

The installation shall include for all required interconnections and sundries between the sensor and control unit.

The flow meter must be installed on a straight and unobstructed length of pipe. The length of pipe upstream and downstream from the flow meter shall conform to the following minimum straight and unobstructed lengths required before any bend or obstruction occurs:

- Upstream of flow meter – A length greater or equal to 15 times the diameter of the pipe; and
- Downstream of flow meter – A length greater or equal to 5 times the diameter of the pipe.

36.6.5 Instrument Cabinet

Instrument cabinets are required to house the flow convertor, indicators / integrators, surge protection, etc. of each flow meter system. The instrument cabinets shall have the following dimensions:

- Height – 645 mm;
- Width – 435 mm; and
- Depth – 250 mm.

The minimum IP rating of these instrument cabinets shall be IP66. The panels and doors of these instrument cabinets shall be constructed from reinforced glass fibre / impregnated polyester. The instrument cabinets shall be wall mounted with 4 stainless steel wall mounting lugs giving a space of at least 10 mm between the enclosure and the wall.

The instrument cabinets shall be fitted with a painted metal chassis of at least 2.5 mm thick. The instrument cabinet shall be fitted with a glazed door that allows viewing of the indicators and integrators. The window of the door shall be at least equal to 50% of the total area of the door part of the enclosure.

The door shall be removable and have concealed hinges and captive stainless-steel hinge pins. The door shall have an in situ moulded polyurethane sealing gasket fitted to a groove and two closure points that are situated outside of the sealed area. It shall be fitted with at least one cylindrical barrel type lock and two keys shall be supplied with each cabinet. The mechanical resistance of the enclosure with the glazed door shall comply with IK08 (5 Joules to standards EN50102).

The instrument cabinet shall also be fitted with a full-size internal door for mounting of the totalizers and integrators. The internal door shall be reversible. Each instrument cabinet shall be fitted with a M10 brass bolt, two brass nuts and two rubber washers that will act as an equi-potential bar. All surge protection in the enclosure shall be grounded onto this bolt.

36.6.6 Cathodic Protection

All pipes shall be cathodic protected, and the Contractor shall ensure that all requirements for the flow meter systems as installed in cathodic protected pipelines are met. All special modifications, excluding insulating flanges, common and cross bonding and other related CP requirements at the flow meter system, shall be included in the rate for supplying the meter.

For all installation requirements, specifications and standards regarding cathodic protection for the MCWAP-2 refer to Section 34 – AC Mitigation and Cathodic Protection.

36.6.7 Electrical Surge Protection

The Contractor shall, apart from his own defined requirements, provide for the supply, installation and commissioning of the following surge protection that shall be equal or similar to that as supplied by Surgetek:

36.6.7.1 Single Pole for Zone 0_b – 1, Class B

One for each flow meter system, in accordance with E DIN VDE 0675-6:1989-11 and –6/A1:1996-03 fitted with zinc oxide varistor, Dehn guard.

- Rated voltage 275 VAC;
- Max Discharge current (8/20): 40 kA;
- Response time < 25 ns; and
- 35 mm din rail mounting.

36.6.7.2 Surge Arrester for Tt Systems, for Zone 0_b – 1, Class C

One for each flow meter system, in accordance with E DIN VDE 0675-6:1989-11, –6/A1: 1996-03 and –6/A2:1996-10 as spark gap type arrester, Dehn gap.

- Rated voltage 255 V/ 50 Hz;
- Nominal discharge current (8/20): 20 kA;
- Response time < 100 ns;
- Voltage protection level: 1500 V; and
- 35 mm din rail mounting.

36.6.7.3 Surge Protection Device Class D

One for each flow meter system, a two-pole surge protection device with supervisory and disconnection device. Class D device in accordance with E DIN VDE 0675-6:1989-11 and –6/a1:1996-03, Dehn rail.

- Nominal voltage 230 VAC;
- Nominal Current 16 A;
- Nominal Discharge current (8/20): 3 or 5 kA;
- Response time <25 or 100 ns;

- Protection level <1.5 kV; and
- 35 mm din rail mounting.

36.6.7.4 Modular Surge Arrester

Four for each flow meter system, a two pole, universal current / surge arrester in modular terminal block system. Device in accordance with IEC 61312-1, Blitsductor.

- Nominal voltage 2 VAC/DC;
- Nominal Current 6 A;
- Nominal Discharge current (8/20): 3 or 5 kA;
- Response time <25 or 100 ns;
- Protection level <1.5 kV; and
- 35 mm din rail mounting.

36.6.7.5 Isolating Spark Gaps

Two for each flow meter system, isolating spark gaps of the Type ExFS, Imp 100 kA (10/350).

- Ac spark over voltage < 2.5 kV;
- 100% standard lightning spark over voltage (1.2/50);
- Enclosure steel with external weather-proof plastic coating;
- Cable length 300 mm; and
- Complete with connection bracket Type IF 1.

36.6.7.6 Earth Bars

For each flow meter system two (2) Earth bars with a Cross section not less than 90 mm^2 fitted with two terminals for 30 mm copper flat bar, two terminals for 16-95 mm^2 conductors and four terminals for less than 16 mm^2 conductors. Terminal bar to be at least 190 mm long with two bar holders and a plastic cover.

36.6.7.7 Copper Cable

50 metres of stranded copper cable for connection of the pipeline spark gaps to the earth mats and the instrument cabinet equi-potential earth point to earth mat. Cross sectional area not less than 70 mm^2. Complete with appropriately sized crimped lugs. They must be secured at intervals not more than 500 mm apart.

36.6.8 Accuracy

The accuracy of the meter shall be guaranteed equal or better than:

- 100.0 ± 1.0 % of full scale.

36.6.9 Power Requirements

The meter shall be fed from 24 V DC supply. The meter shall have battery back-up capable of providing 24 V DC power to the meter for a minimum period of 72 hours in case of a power failure.

The batteries shall be of the deep cycle rechargeable type of batteries.

36.7 ULTRASONIC IN-LINE 3-BEAM FLOW METERS

36.7.1 General

All 3-beam flow meters shall be microprocessor based in-line flow meters and shall be able to be programmed to read flow accurately passing through any pipe.

The meter shall have a low signal-to-noise ratio and shall be able to damp acoustic signals.

The instrument shall be able to measure bidirectional flow.

36.7.2 Operating Principle

Two diagonally opposed ultrasonic sensors function as transmitter and receiver. The sound signal alternatively emitted from both is accelerated by the flow and slowed against the flow.

The difference in the time the signal requires to travel between the two diagonally opposite ultrasonic sensors is directly proportional to the mean flow rate from which the volumetric flow can then be calculated.

Using extra transducers to create several flow paths, flow profile aberrations can be compensated for. This greatly increases the accuracy of the instrument.

The meter shall be able to deal with water with a maximum solid content of 5%.

36.7.3 Construction

The ultrasonic flow meter shall consist of two parts, namely a 3-beam in-line flow sensor and a flow convertor.

The protection class shall conform to IP67 / NEMA 6.

The measuring functions shall show at least the actual instantaneous rate of flow as well as the totalized volume of flow.

The meter shall be corrosion protected as well as resistant to UV radiation.

The flow convertor shall be constructed of die-cast aluminium polyurethane coated material.

All outputs shall be galvanically isolated.

The signal converter shall provide multiple outputs (MIMO technology).

Communication interface options shall include the following for integration into third party systems:

a) 4 – 20 mA;

b) Modbus TCP/IP;

c) Foundation Fieldbus;

d) PROFIBUS DP;

e) PROFIBUS PA; and

f) PROFINET IO.

Shall include custody transfer approvals like OIML R 49 and R 117-1, MI-001, MI-004 and MI-005.

Under the PROFINET IO option, real time Ethernet communication shall be connected to the IoT (Internet of Things). PROFINET IO shall be connected to PLC Units via network switches using either point to point network topology, ring network topology or the star network topology.

The output of the flow convertor shall be current, pulse and status output. The output shall be galvanically isolated.

The flow convertor shall be equipped with a large graphic display and be backlit with graphics. Configuration shall be direct or via an infrared interface for reading and writing of all parameters. The flow convertor shall have optical buttons for operator control without opening the housing. The flow convertor shall support MIMO (Multiple Input Multiple Output) technology. The flow convertor shall display the following:

- A pulse output non-resettable flow totalizer, totalizing in l/s, m^3/s, m^3/h, m^3 x 100, etc.;
- A current output flow rate indication in l/s, m^3/s, m^3/h, m^3 x 100, etc.; and
- A status output for alarm signalling to Control System.

The flow convertor shall also have a galvanically isolated 4-20 mA output linear to flow that shall be connected to a Control System. This 4-20 mA output signal shall act as a “Re-transmit” function and shall not influence the operation and functionality of the flow meter system.

The flow convertor shall provide an integral diagnostic feature to monitor all internal circuitry and identity errors. The level of such errors shall be identified as fatal, permanent or warning and be logged and stored. The minimum requirement is that the last 9 errors are to be stored in the memory of the flow convertor for a minimum period of 180 days.

A warning icon shall appear on the display when an error occurs. It shall be possible for the operator to view the error-code associated with the fault via a service menu on the display.

Access to the menu structure to effect changes to the settings shall be protected by a personal identification number (PIN) to prevent unauthorized tampering. Authorised personnel must however be allowed access to change the PIN if and when required.

In “Viewing Mode”, the operator must be able to scroll through the settings and readings without allowing him to change any of the settings, unless he knows the PIN.

The requirements for the current, pulse and status output shall conform to the following minimum specifications:

- The pulse output or frequency output shall be user selectable;

- Analogue output: 4 – 20 mA. The time constant shall be adjustable between 0.1 and 30 seconds;
- Frequency output: Frequency: 0-10 kHz, 50% duty cycle, adjustable 500 Hz, 1 kHz, 5 kHz, 10 kHz with adjustable time constant selectable between 0.1 to 30 seconds;
- Pulse output: User selectable negative / positive pulse with adjustable pulse widths from 64 µs to 4.2 seconds with selectable volume unit / pulse; and
- Status output: Change-over type 42 VAC, 2 A or 24 V DC, 1 A selectable as error or control or for low or high flow limit switch with adjustable hysteresis.

36.7.4 Installation

The signal cable must be able to carry the flow signal to a maximum distance of 500 metres without the need for additional signal repeaters or conditioners.

The isolation spark gaps to be installed on the pipeline in the manhole shall conform to the Drawings and Section 28 – Mechanical General. These isolation spark gaps shall be connected via the earth bars onto the earth point as supplied by the pipeline Contractor.

The instrument installation shall include for all interconnections and sundry requirements between sensor and control / amplifier unit.

A removable EEPROM with flow sensor data stored in the EEPROM shall be provided with the flow sensor and shall contain the following:

- Serial Number;
- Sensor Size; and
- Calibration Factor.

Between the flow sensor and flow convertors, there shall be two separate lengths of 3-core, multi-strand, 1.0 mm^2 individually insulated with an overall braided screened instrumentation cable.

The instrument cabinet fitted with the flow convertor, electrical surge protection and related Plant items shall be installed against the wall inside the flow meter chamber.

The installation shall include for all required interconnections and sundries between the flow sensor and flow convertor.

The flow meter must be installed on a straight and unobstructed length of pipe. The length of pipe upstream and downstream from the flow meter shall conform to the following minimum straight and unobstructed lengths required before any bend or obstruction occurs:

- Upstream of flow meter – A length greater or equal to 5 times the diameter of the pipe (5ND<L<10ND); and
- Downstream of flow meter – A length greater or equal to 3 times the diameter of the pipe (3ND<L<5ND).

The flow meter flanges shall be suitable for the rating of the operating pressure and related pipe work at the proposed location as indicated on the Drawings. The instrument shall be able to measure bidirectional flow.

36.7.5 Type Testing

Type tests shall have been performed on Plant to be supplied under this Contract. Type test certificates to be submitted with tender documents. The Testing authority shall be traceable and internationally recognised.

36.7.6 Instruction Manuals

For all information regarding training of personnel on the MCWAP-2, refer to Section 48 – Tests on Completion.

36.7.7 Calibration Certificate

A manufacturer's calibration certificate, proving that calibration was performed at least twice at two calibration points, shall be supplied with each flow sensor. Operation and Maintenance Manuals.

Submission of O&M Manuals shall be as required under Clause 48.9.

36.7.8 Marking and Labels

Each primary element shall be clearly marked with the following information on the body of the primary element:

- Serial Number;
- Year of manufacture;
- Size;
- Supplier's name;
- Pressure rating; and
- Maximum velocity.

This information shall be engraved on a non-detachable metal disk with lettering at least 10 mm high and 5 mm wide.

For marking and labelling of the instrument and electrical cabinets or kiosks, refer to Section 39 – Electrical - Plant and Installation.

36.7.9 Training

For all information regarding training of personnel on the MCWAP-2, refer to Section 48 – Tests on Completion.

36.7.10 Commissioning

Only instruments that can be programmed with ease and without specialized knowledge or Plant shall be considered. It shall further be performed without the use of additional external equipment such as laptops or desktop computers.

The Contractor shall in advance inform the Engineer of how commissioning will be done on site and what is required to ensure re-calibration of the flow convertor and sensor in the case of replacement on site of any of the items.

All other variables are to be programmed into the flow convertor using a user-friendly cascading menu structure.

In the event of a faulty or missing EEPROM or any other memory device, the menu structure shall allow for the manual programming of calibration information or data.

36.7.11 Guarantee

For all information regarding the guarantees pertaining to electronic Plant and instrumentation Plant of the MCWAP-2, refer to Section 48 – Tests on Completion.

36.7.12 Reducer Pieces

Reducer pieces shall be manufactured to comply with the minimum requirements for the flow sensor.

Reducer pieces shall be manufactured from the same type and quality steel plate as would the relevant straight pipe for the same duty. Reducer pieces shall not have more than two longitudinal weld seams and the tapered portion shall be at least five times the length of the tapering difference.

Tapered sections shall have a maximum angle of divergence of 10^{o}.

36.7.13 Flanges and Gaskets

For all specifications and standards regarding the flanges and gaskets to be used for MCWAP-2, refer to Section 28 – Mechanical General.

36.7.14 Insulating Flanges

For all specifications and standards regarding the insulating flanges required for MCWAP-2, refer to Section 28 – Mechanical General and Section 34 AC Mitigation and Cathodic Protection.

36.7.15 Instrument Cabinet

Instrument cabinets are required to house the flow convertor, indicators / integrators, surge protection, etc. of each flow meter system. The instrument cabinets shall have the following dimensions:

- Height – 645 mm;
- Width – 435 mm; and
- Depth – 250 mm.

The minimum IP rating of these instrument cabinets shall be IP66. The panels and doors of these instrument cabinets shall be constructed from reinforced glass fibre / impregnated polyester. The instrument cabinets shall be wall mounted with 4 stainless steel wall mounting lugs giving a space of at least 10 mm between the enclosure and the wall.

The instrument cabinets shall be fitted with a painted metal chassis of at least 2.5 mm thick. The instrument cabinet shall be fitted with a glazed door that allows viewing of the indicators and integrators. The window of the door shall be at least equal to 50% of the total area of the door part of the enclosure.

The door shall be removable and have concealed hinges and captive stainless-steel hinge pins. The door shall have an in situ moulded polyurethane sealing gasket fitted to a groove and two closure points that are situated outside of the sealed area. It shall be fitted with at least one cylindrical barrel type lock and two keys shall be supplied with each cabinet. The mechanical resistance of the enclosure with the glazed door shall comply with IK08 (5 Joules to standards EN50102).

The instrument cabinet shall also be fitted with a full-size internal door for mounting of the totalizers and integrators. The internal door shall be reversible. Each instrument cabinet shall be fitted with a M10 brass bolt, two brass nuts and two rubber washers that will act as an equi-potential bar. All surge protection in the enclosure shall be grounded onto this bolt.

36.7.16 Cathodic Protection

All pipes shall be cathodic protected, and the Contractor shall ensure that all requirements for the flow meter systems as installed in cathodic protected pipelines are met. All special modifications excluding insulating flanges, common and cross bonding and other related CP requirements at the flow meter system, shall be included in the rate for supplying the meter.

For all installation requirements, specifications and standards regarding cathodic protection for the MCWAP-2 refer to Section 34 – AC Mitigation and Cathodic Protection.

36.7.17 Electrical Surge Protection

The Contractor shall, apart from his own defined requirements, provide for the supply, installation and commissioning of the following surge protection that shall be equal or similar to that as supplied by Surgetek:

36.7.17.1 Single Pole for Zone 0_b – 1, Class B

One for each flow meter system, in accordance with E DIN VDE 0675-6:1989-11 and –6/A1:1996-03 fitted with zinc oxide varistor, Dehn guard.

- Rated voltage 275 VAC;
- Max Discharge current (8/20): 40 kA;
- Response time < 25 ns; and
- 35 mm din rail mounting.

36.7.17.2 Surge Arrester for Tt Systems, for Zone 0_b – 1, Class C

One for each flow meter system, in accordance with E DIN VDE 0675-6:1989-11, –6/A1: 1996-03 and –6/A2:1996-10 as spark gap type arrester, Dehn gap.

- Rated voltage 255 V / 50 Hz;
- Nominal discharge current (8/20): 20 kA;
- Response time < 100 ns;

- Voltage protection level: 1500 V; and
- 35 mm din rail mounting.

36.7.17.3 Surge Protection Device Class D

One for each flow meter system, a two-pole surge protection device with supervisory and disconnection device. Class D device in accordance with E DIN VDE 0675-6:1989-11 and –6/a1:1996-03, Dehn rail.

- Nominal voltage 230 VAC;
- Nominal Current 16 A;
- Nominal Discharge current (8/20): 3 or 5 kA;
- Response time <25 or 100 ns;
- Protection level <1.5 kV; and
- 35 mm din rail mounting.

36.7.17.4 Modular Surge Arrester

Four for each flow meter system, a two-pole, universal current / surge arrester in modular terminal block system. Device in accordance with IEC 61312-1, Blitsductor.

- Nominal voltage 24 VAC/DC;
- Nominal Current 6 A;
- Nominal Discharge current (8/20): 3 or 5 kA;
- Response time <25 or 100 ns;
- Protection level <1.5 kV; and
- 35 mm din rail mounting.

36.7.17.5 Isolating Spark Gaps

Two for each flow meter system, isolating spark gaps of the Type ExFS, Imp 100 kA (10/350).

- Ac spark over voltage < 2.5 kV;
- 100% standard lightning spark over voltage (1.2/50);
- Enclosure steel with external weather-proof plastic coating;
- Cable length 300 mm; and
- Complete with connection bracket Type IF 1.

36.7.17.6 Earth Bars

For each flow meter system two (2) Earth bars with a Cross section not less than 90 mm^2 fitted with two terminals for 30 mm copper flat bar, two terminals for 16-95 mm^2 conductors and four terminals for less than 16 mm^2 conductors. Terminal bar to be at least 190 mm long with two bar holders and a plastic cover.

36.7.17.7 Copper Cable

50 metres of stranded copper cable for connection of the pipeline spark gaps to the earth mats and the instrument cabinet equi-potential earth point to earth mat. Cross sectional area not less than 70 mm^2. Complete with appropriately sized crimped lugs. They must be secured at intervals not more than 500 mm apart.

36.7.18 Accuracy

The accuracy of the meter shall be guaranteed equal or better than:

- 100.0 $\pm$ 0.5 % of full scale.

36.7.19 Power Requirements

The meter shall be fed from 24 V DC supply. The meter shall have battery back-up capable of providing 24 V DC power to the meter for a minimum period of 72 hours in case of a power failure.

The batteries shall be of the deep cycle rechargeable type of batteries.

36.7.20 Storage, Handling and Transport

Flow sensors shall be protected against damage at all stages from manufacture to delivery. Particular care shall be taken to protect the ends of all flow sensors against denting. Flow sensors shall be transported and stacked in a manner such as to prevent deformation. Dents causing a protrusion into the interior of a pipe or into the outer cover of the coils shall result in the flow sensor being rejected.

Satisfactory temporary end covers shall be provided for the protection of primary elements to prevent damage to the internal lining during transportation and during handling on Site.

Primary elements shall be so transported, stored and handled that the primary elements are not stressed at any time and fittings are not damaged in any way. Any defective equipment shall be removed from the Site at no cost to the Employer.

The primary elements shall at all times be handled with approved equipment, employing stout, wide canvas or rubber-covered slings and wide padded skids designed to prevent damage to the exterior coating. The slings shall be at least 300 mm wide for pipes up to DN 600, 500 mm wide for pipes of DN 700 and up to DN 1200 and 800 mm wide for pipes of DN 1400 and larger or as approved.

Bare cables, chains, hooks, metal bars, or narrow skids shall not be allowed to come in contact with either the exterior coating or the interior lining of the primary element.

The Contractor shall be responsible for the transport of all flow meter equipment to Site, off-loading and storage on Site, all in accordance with the Specifications.

36.7.21 Information and Drawings to be submitted

Sufficient information shall be supplied with the tender giving enough information to make a proper assessment of the flow meter systems offered. Information supplied shall include (but not necessarily be limited to):

- Technical details of the flow meter systems;
- Principle of operation;
- Installation requirements;
- Earthing and surge protection detail including the name of the supplier of the surge suppression units and technical details of units tendered;
- Supplier detail and technical detail for the instrument cabinet, totaliser and digital display units; and
- Effect of cathodic protection on the flow meter system and special requirements.

36.8 SPARE PARTS REQUIREMENTS

Spare parts requirements are defined by a combination of that defined by the Employer and that defined by the Contractor based on the recommendations made by the manufacturers and suppliers of specific Plant items.

A Spare Part Schedule by the Employer is available in Section 48 – Test on Completion.

Over and above the Employers defined requirements for spares, the Contractor shall list 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. The lists of additional critical spare parts must be submitted to the Engineer prior to achieving RFTO.

36.9 MEASUREMENT 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 Section1 – General.

36.001 Design and Documentation Unit: Included

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, loop diagrams and wiring diagrams, Control System layout diagrams, Control Network layout diagrams, SCADA graphic layouts, engineering software code, engineering design philosophy, control philosophy, 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 48.9 of Section 48 – Tests on Completion and paid as per Item 48.003.

36.002 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; 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.

a) Electromagnetic flow sensor and flow convertor **Unit: number (No)**

The rate shall include the Electromagnetic flow sensors and flow convertors as per the Technical Schedules, complete with both flow sensor and flow convertor, carbon steel flanges, carbon steel measuring tube, stainless steel flow sensor housing, stainless steel connection box, stainless steel transducer window, instrumentation cable, die-cast aluminium flow convertor housing, 3-field LCD backlit high contrast display, communication module with current, pulse and status outputs, brackets and pedestals, enclosures, interconnecting cables, surge protection and all other sundry requirements.

b) Ultrasonic clamp-on flow sensor and flow convertor **Unit: number (No)**

The rate shall include the ultrasonic clamp-on flow sensors and flow convertors, complete with instrumentation cable, field mounted flow convertor with a die-cast aluminium housing, 3-Field LCD backlit high contrast display, galvanically isolated inputs and outputs, communication module with current, pulse and status outputs, brackets and pedestals, enclosures and surge protection.

c) Ultrasonic 3-Beam inline flow sensor and flow convertor **Unit: number (No)**

The rate shall include the ultrasonic 3-Beam inline flow sensors and flow convertors as per the Technical Schedules, complete with carbon steel flanges, carbon steel measuring tube, stainless steel housing, stainless steel transducer window, instrumentation cable, field mounted flow convertor with a die-cast aluminium housing, 3-Field LCD backlit high contrast display, galvanically isolated inputs and outputs, communication module with current, pulse and status outputs, brackets and pedestals, enclosures and surge protection.

36.003 Installation of Plant

The rates tendered shall include for full compensation for the installation of the Plant on Site including the provision of all labour, transport, materials (inclusive of fasteners) 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; 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 in Section 48 – Tests on Completion.

a) Electromagnetic flow sensor and signal convertor **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the Electromagnetic flow sensors and flow convertors as per the Technical Schedules, complete with both flow sensor and flow convertor, carbon steel flanges, carbon steel measuring tube, stainless steel flow sensor housing, stainless steel connection box, stainless steel transducer window, instrumentation cable, die-cast aluminium flow convertor housing, 3-field LCD backlit high contrast display, communication module with current, pulse and status outputs, brackets and pedestals, enclosures, interconnecting cables, surge protection, inclusive of all labour, installation materials and sundries for a fully operational and serviceable installation.

b) Ultrasonic clamp-on flow sensor and signal convertor **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the ultrasonic clamp-on flow sensors and flow convertors as per the Technical Schedules, complete with control units, brackets and pedestals, enclosures, interconnecting cables, surge protection, inclusive of all connected exterior indicating and control loops, all labour, installation materials and sundries for a fully operational and serviceable installation.

c) Ultrasonic 3-Beam inline flow sensor and flow convertor **Unit: number (No)**

The rate shall include full compensation for the installation, testing and pre-commissioning of the ultrasonic 3-Beam inline flow sensors and flow convertors, inclusive of carbon steel flanges, carbon steel measuring tube, stainless steel housing, stainless steel transducer window, instrumentation cable, field mounted flow convertor with a die-cast aluminium housing, 3-Field LCD backlit high contrast display, galvanically isolated inputs and outputs, communication module with current, pulse and status outputs, brackets and pedestals, enclosures and surge protection for a fully operational and serviceable installation.

36.004 Spares **Unit: Provisional sum (Prov. sum)**

The payment for specific spare items required by the Employer shall be made per item listed in the Commissioning and Trial Operation parts of the Bill of Quantities. Payment Item 48.007 is relevant in this regard.

Payment for spares identified by the Contractor as per Clause 36.8 and approved by the Engineer, shall be made from the provisional sums allowed for this in the Bill of Quantities. The rates provided for these spares 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.