SPECIFICATION:

HEAVEY DUTY CONCRTE SECURITY ENCLOSURE

Client: Transnet Pipelines (SOC)

Objective: The provision of a vandal resistant enclosure for the housing of TRUs, FDUs and NDU in vandal prone areas throughout the Transnet Pipelines (TPL) network

Application: Vandal prone areas

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The enclosure shall meet the following minimum requirements:

- The enclosure shall not have any visible areas of weakness
- The enclosure shall be constructed from concrete and have a minimum wall strength of at least 50 MPa
- The enclosure shall have the following minimum dimensions:
    - Plan – 2100mm X 2100mm
    - Front Height – 2300mm
    - Rear Height – 2250mm (50mm roof slope to let rain water run off) Wall Thickness – 150mm
    - Base (Slab) – 3000mm X 3000mm X 200mm (with a cable sleeve positioned accordingly)
    - Ventilation hole or temperature control
- The door shall be a heavy-duty steel door, constructed from 50mm steel. The annular spaces shall be filled with at least 30 MPa concrete and shall have a double key locking system with a removable door handle.

THIS SPECIFICATION COVERS THE REQUIREMENTS FOR CATHODIC PROTECTION TRANSFORMER RECTIFIER UNITS AND FORCED DRAINAGE UNITS

PL 652

REV. 001

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1. SCOPE

This specification covers Transnet Pipelines CP Department's requirements for Transformer Rectifier Units (TRU) and Forced Drainage units (FDU).

2. SERVICE CONDITIONS

2.1 Environmental

The equipment shall be designed and constructed to comply with the requirements of this specification when operating under the following conditions.

Altitude	:	Sea level to 1800m above sea level
Ambient temperature	:	-5 to 50ºC
Relative Humidity	:	10% to 90%
Lightning Conditions	:	11 Flashes / sq. Km / annum

Units may be used in environments where metallic dust, soot and grit may be present.

3. FRAME SPECIFICATION

3.1 Rectifier's Frames (For Indoor use)

a. Size of frame to be able to fit through door with dimensions of 1000mm wide 1700mm high without having to dismantle the TRU/FDU/NDU
b. All frames shall be hot dipped galvanised.
c. Lifting lugs shall be fitted to the top of the frame to facilitate lifting by means of a crane.
d. The base shall be mounted on channel iron to facilitate lifting by means of a forklift.
e. All components shall be mounted on a single frame; easy access to any components shall be possible.

f. Power diodes or thyristor stack is to be mounted in such a position as to facilitate quick replacement.
   Gland plate shall be mounted to hold all terminated cables.

4. PRINTED CIRCUIT BOARDS (PCBs)

a. All electronic printed circuit boards and mounted components shall be adequately coated with a proprietary conformal specification coating designed to prevent corrosion.
b. Printed Circuit Boards (PCBs) shall have a primary solder mask and be screen printed to legend all components.

5. GENERAL SPECIFICATION FOR ELECTRICAL WORK

a. Wiring and selection of components shall as a minimum comply to SANS 10142 (Latest Edition)
b. All current carrying conductors shall be insulated to withstand a minimum voltage of 1000V.

Wherever possible flexible, multi-strand cabling shall be used.

c. Joints or splices in wiring shall not be permitted.
d. No more than two wires shall be connected to any one terminal.
e. All conductors excluding busbars shall be routed in trunking or harnessed using polyethylene spiral wrapping.
f. All current carrying conductors shall be adequately sized to continuously carry the design current without noticeable rise in temperature.
g. All conductors shall be terminated at each end with a suitably sized, pre-insulated lug and be crimped with a suitable crimper (Dimple crimps shall not be permitted).
h. No trimming of conductor strands shall be permitted.
i. All non-insulated lugs shall be crimped by means of a hydraulic hexagonal crimping tool using the correct size die.
j. Cable markers must be of appropriate size to suit the insulation size of the cable.
k. Cable markers shall read from left on horizontal conductors and from cable to lug on vertical conductors.
l. All AC conductors shall be colour coded and numbered according to the incoming phase and retain the same colour throughout the unit.
m. Wire numbering shall change after every device.
n. AC carrying conductors must be routed separately from DC carrying conductors.
o. Grounding cable connections to surge devices must be kept as short as possible and may not be routed with either AC or DC carrying conductors.
p. Grounding cable connections to surge devices shall have very slow bends (minimum radius 20 times the external diameter of the conductor being used).
q. Input voltage (source) 240V single phase, 3phase 400V

6. BUSBARS

a. Suitably rated busbars must be used on the secondary side of the primary transformer.
b. Busbars shall be tinned copper.
c. Busbars shall be sized according to the current that they are expected to carry but shall not be less than minimum size as stated at point 6.d. (Current density shall not exceed 0,5A/mm²).
d. Minimum size of busbar shall not be less than 30mm X 5mm.
e. Busbars shall be bolted and not welded.
f. When bolting the mating surfaces shall be covered with conductive water repellent paste prior to assembly.

g. Spring washers behind the nuts shall be used when bolting busbar joints.

7. TERMINALS

a. All terminals shall be completely accessible after completion of wiring.
b. All terminations made to busbars shall be provided with spring washers.
c. All supply power terminals shall be fully enclosed and be highlighted with warning labels.
d. Transformer, inductor and smoothing capacitor terminations shall be covered with a transparent cover prohibiting accidental contact.
e. Output terminals shall be insulated from any metal housing or chassis.
f. All terminals shall be clearly marked and be appropriately sized for the current they are expected to carry.

8. GENERAL SPECIFICATION FOR COLOUR CODING AND LABELLING OF CONDUCTORS, EQUIPMENT AND COMPONENTS.

8.1 Cables Colour Coding

The following cables mentioned below shall be connected or terminated to the Rectifier's gland plate.

a. Positive DC Conductor — Red

b. Negative DC Conductor — Black

c.	Monitor cable	Black
d.	Coupon Cable	Black
e.	Earth Cable	Green with Yellow stripe
f.	AC Phase 1	Red
g.	AC Phase 2	White
h.	AC Phase 3	Blue
i.	Neutral	Black
j.	Reference electrode cable	yellow
k.	Transformer secondary cables	Grey
l.	Electrical warning signs	Black on Yellow back ground
m.	Component labels	Black on white back ground

n. All labels shall be engraved sandwich type trifoliate labels.

o. All labels shall be mounted with machine screws or blind rivets only.

8.2 Rectifier's Equipment Labelling

All rectifiers components and cables shall be labelled as follows: -

a. Labels shall cross reference to the circuit diagram.
b. Labels shall be of the engraved "sandwich" type (trifoliate) with black letters on a white background.
c. Labels are in upper case letters with a height of 6mm for component labels and 10mm for output terminal labels.
d. Output terminals shall be labelled as follows: -

+ GROUNDBED

- PIPE

PIPE MON

REF ELECT

COUPON

EARTH

e. Cables shall be identified by means of permanently marked ferrules with black lettering on a white background. Ferrules shall be slip-on-type and matched to the size of the cable.

f. Ferrules shall be situated so as to read right way up on horizontal cables and from lug to insulation on vertical cables.

9. ELECTRICAL CONSTRUCTION

9.1 General

a. All work shall comply with SANS 10142 and incorporated standards (latest edition).

b. The TRU shall consist of: - a step-down double wound transformer with an earth screen between the primary and secondary windings, course voltage tapings on secondary side of transformer and the diode stack or thyristor stack to produce the DC output.

c. The maximum output voltage and output current will be specified as per BOQ at tender stage.

d. All FDU's and NDU's shall be supplied by the suitably rated isolator to isolate the unit from the load for maintenance purposes.

e. A suitably rated and discriminated circuit breaker shall be provided on the incoming supply to ensure local tripping in the event of a fault on the unit.

f. The TRU/FDU shall consist of either a single phase or three-phase step down transformer and an automatically and manually controlled rectification circuit.

g. The TRU/FDU's output shall be capable to be controlled on three types of control modes, as follows:

- Constant Voltage
- Constant Current
- Constant Potentials

h. Constant Voltage – the rectifier will maintain the same set point of output voltage for the desired pipe potentials.

i. Constant Current – the rectifier will maintain the same set point of output current for the desired pipe potentials.

j. Constant Potential – the rectifier will maintain the pipe potentials at the set point and all times, should the pipe potentials increase due to stray current to more than the set point,

the rectifier will automatically go to sleeping mode up until the pipe potentials are below the set point.

k. The rectifier bridge shall consist of silicon diodes or silicon thyristors connected to a full wave rectification, which shall be rated at twice the rated current and have a peak inverse voltage of not less than 1600 volts.

l. The FDU rectifier shall be capable to automatically drain the stray current from the pipe to the rail without compromising the pipe potentials. During the stray current draining period, the rectifier will be on a sleeping mode (i.e. the TRU part will be automatically switched "OFF" and the NDU part will automatically switched "ON") up until the stray current has been fully drained from the pipe.

m. The diode/thyristor stack shall be mounted on a naturally cooled heat sink.

n. All bridge rectifier diode/thyristor stack shall be protected by suitably rated semi-conductor fuses.

o. The unit output shall be smoothed (the unit shall be fitted with an effective filtering circuit) such that the "ripple" is less than 2% across the full load output range.

p. The TRU and FDU shall be supplied with isolated outputs for telemetric (Remote Monitoring Unit) interface or data logging devices.

r. Cables shall be terminated at each end by means of suitable lugs.

s. Power cables lugs shall be insulated by means of heat shrink sleeves or slop-on rubber shrouds and colour coded accordingly.

q. Terminals on power connections shall be provided with lock nuts and spring washers.

r. Output terminals shall be fully insulated from the metal of the housing and will comprise of brass bolts. Each provided with nuts, lock nuts, washers and tinned copper cable lugs suitable for the specified cable size.

9.2 **Transformer**

a. All transformers shall be double wound to BS171 standard complete with an inter-winding screen.

b. The transformer shall be a step down, double wound power transformer requiring a 230V, 50Hz (single phase unit) or 400V, 50Hz supply (three phase unit).

c. The inter-winding screen must be routed out of the transformer and earthed as close to the transformer mounting as possible.

d. The transformer is to be vacuum impregnated with a suitable insulating vanish and baked subsequence to vacuum impregnation.

e. Transformer tapings shall be provided at 20%, 40%, 60% and 80% of the maximum output voltage.
f. The TRU shall be provided with multiple tapings on the secondary of the Transformer and the Supplier to specify suitable tapings (e.g. 3, 6, 12, 18, 24, 48).

9.3 Earthing

a. The surge diversion units shall be all connected to the common earth incorporating the primary AC supply earth, transformer screen and the transformer rectifier housing.
b. The common earth consists of 30 x 3mm tinned copper or 40 x 5mm aluminium busbar, and shall be connected to a local earth by means of two 35mm² copper cables.
c. All metal components shall be connected to the common earth and to the AC supply earth.
d. All electrical circuits shall be floating with respect to earth.
e. All connections within the enclosure shall be as short as possible and rated to withstand the prospective fault current.
f. Earth busbar mounting studs shall be of an adequate size to accommodate collective fault currents.

9.4 Auxiliary Power Socket Outlet

a. A 240VAC 15A switch socket outlet shall be provided on the frame of the TRU/FDU.
b. The socket outlet shall be provided with earth leakage protection and be fed from a dedicated circuit breaker (20A recommended).

9.5 Rectifier's Meters

a. The rectifier shall include high quality meters to display the following:

    1. AC Voltmeter - for the measurement of the incoming AC supply voltage
    2. DC Voltmeter - for measurement of output Rectifier's voltage
    3. DC Ammeter - for measurement of output Rectifier's current
    4. DC Voltmeter - for measurement of Pipe-to-soil potentials
    5. KWH meter – for measurement of power consumption

b. All meters shall be of the analogue type.
c. All meters shall be 96mm square with an accuracy of 1,5% of maximum reading.
d. All meters are to be suitably labelled.

e. The DC voltmeter shall have a glass fuse in each lead.
f. The DC ammeters shall be connected up to the DC Current Transformer (CT) or shunt.
g. The DC meters are to have captive female terminals (banana jacks), coloured red and black, for checking the appropriate measurements.
h. The ammeter shall indicate the value of the shunt.
i. All meters are to be flush mounted such that the housing is insulated from the mounting plate.

10. RECTIFIER CONTROLLER

The rectifier's output shall be capable or configured to be controlled by either: -

a. The automatic electronic card control system – the digital three-term PID close loop feedback controller or PLC controller, etc. (this type of controller shall have a LCD display that will display the mode setting, the set point potentials and the measured actual potentials).
b. The manual output rectifier controller – the rectifier shall be able to be controlled manually in case that the automatic electronic card control system is faulty. The unit can either be controlled by using adjustable output ports, Variac or Magnetic amplifier, etc.

11. SURGE PROTECTION

a. Surge protection devices shall be installed on the incoming mains immediately downstream of the main circuit breaker.

The surge protection device must be rated at a discharge current of 40kA and the maximum permitted operating voltage to be 25% above the RMS value of the supply voltage.

b. The response time of the over voltage device is to be less than 25ns.
c. Where three phase units are implemented, then the surge protection device must be connected between each phase and earth. Single phase units to have the surge protection device connected between live and earth.
d. Surge protection devices must be installed after the DC fuses situated in the positive and negative legs of the TRU.
e. The surge protection device must be rated at a discharge current of 40kA and a maximum permitted operating voltage to be 25% above the RMS value of the maximum output voltage.
f. Two surge protection devices must be installed between the positive leg and earth and the negative leg and earth.
g. Surge protection devices to be of type DEHNventil or equivalent to match the respective supply system and shall be installed as follows: -
    1. Two off Dehn VM 275 or equivalent, are connected in series between positive and

negative legs.

2. Between the two VM 275 devices, a connection to the earth bar is made via a Dehn VM 275.
3. In addition to the above, a Dehn VM 600 or equivalent, is connected in parallel between the positive and negative legs.
4. This is followed by 0.5mH Choke in the negative leg, and
5. Between positive leg and earth - two parallel Dehn VM 150 MOV in series with a Dehn Ex-FS (120kA) spark gap with Cu-W electrodes, and
6. Between the two Dehn VM 150 MOV and the spark gap described above - a Dehn Ex-FX (120kA) spark gap is connected to the negative leg.
7. All spark gaps have Copper Tungsten electrodes.

12. COMPONENTS LAYOUT AND RECTIFIER'S SPARES

12.1 COMPONENTS LAYOUT

a. Transformers and inductances to be mounted to the bottom of the cabinet /frame and shall not interfere with any gland plate that may be installed.

b. The rectifier and any other heat sinks are to be mounted in the upper section of cabinet / frame.

c. Trunking and any heat sensitive devices must be kept away from the heat sinks.

d. AC and DC current carrying conductors must be routed in separate ducts and or looms and may not be mixed in the same duct or loom.

e. All components must be accessible from the front and must be mounted such that they are easy accessible for removal and in situ repair work.

f. All components must be labelled and cross referenced to the laminated schematic drawing mounted in the cabinet / frame.

12.2 RECTIFIER'S SPARES

a. Spares shall be supplied with the TRU or FDU but not limited to the following:

Fuses	:	Three of each type and rating used
MOV's	:	One of each type and rating
Spark Gaps	:	One of each type and rating
Control card	:	One of each type and rating
Diode	:	One of each type and rating (bypass diode)
Thyristors	:	three of each type and rating

Diode : Three of each type and rating (rectifier diode)

b. The spares shall be mounted at a designated panel on the TRU frame.

13. NATURAL DRAINAGE UNIT (NDU)

a. The NDU's frame shall be manufactured as per section 3.1.
b. The natural drainage unit will consist of 2 Silicon diodes rated at twice the rated current and a peak inverse voltage of 1600 volts.
c. The diodes shall be mounted on a convection cooled heat sink.
d. The natural unit diodes must be protected by 1 by 100A semiconductor fuses.
e. The natural drainage unit will be connected into the circuit after the DC isolator.
f. The natural drainage unit shall operate individually or can be in cooperated with the TRU so that they can both operate as a Forced Drainage Unit (FDU).

14. TESTING AND ACCEPTANCE

a. All rectifiers shall be subjected to factory acceptance testing (FAT) that will be carried out by the manufacture and witnessed by a Transnet Pipeline representative.
b. All tests will be carried out in accordance with the test procedure laid out in PL652 annexure 1.

15. DOCUMENTATION

a. The manufacturer shall provide full detailed documentation (manuals, single line diagrams, schematics etc) as per the TPL specification PL100, PL102 and Pl103 latest revisions.
b. Documentation shall as a minimum be 1 hard copy and 2 soft copies.
c. All drawings shall be in Autocad format.

TPL Sample Quality Control Plan (QCP)

Quality Control Plan No.		Revision:		Date Issued:	
Contract No.		Description:		Item No.	
Contractor		Location:			

Activity No.	Activity Description	Procedure Reference / Code Specification	Specification Acceptance Criteria	Verifying Document / Report / Certificate	Verification/Witness					
					Contractor		**AIA**		**TRANSNET**	
					Action	Sign	Action	Sign	Action	Sign

Rev	Date	Reason for Revision	Drawn	Checked

ACTION

H – Hold. Mandatory Hold Point

R – Review (Verify) only

W - Witness

S - Surveillance

NOTE: H & W points require formal notification to TRANSNET