



A Division of Transnet SOC Limited

TECHNOLOGY MANAGEMENT

SPECIFICATION

REPAIR AND REFURBISHMENT OF OIL-IMMERSED TRACTION AND DISTRIBUTION TRANSFORMERS

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LIST OF AMENDMENTS

Version	Date issued	Summary of changes
01	23/09/1999	Original version
02	03/10/2022	POPIA declaration statement inserted
		Addition of electrical service conditions
		Spoornet changed to Transnet
		Addition of the call out fee, on-site inspections fee and issuing of report to the schedule of breakdown prices.
		Addition of standard for method of sampling
		Amendment to the method of reporting transformer failure
		Removed insurance and delay penalties information
		Addition of transformer repair workshop facility requirements
		Routine testing costs added to breakdown costs

1.0 SCOPE

- 1.1 This specification details Transnet's requirements for the repair and refurbishment of oil immersed traction and power distribution transformers on an "as and when" contract basis.
- 1.2 Traction transformers are installed in 3 kV DC and 25 kV AC traction substations to feed power from the power utility to the Overhead Track Equipment (OHE).
- 1.3 Distribution transformers are installed in distribution substations to either step-up or step-down voltage for the 11kV or 6.6 kV reticulation system. Furthermore, the distribution transformers are used on the wayside as step down points to signal relay rooms.

2.0 BACKGROUND

- 2.1 Transnet has approximately 521 traction transformers and 293 distribution transformers, which comprise of various makes, input voltages, vector groups and kVA ratings as shown in Appendix B. Transformer failures negatively affect substation availability across the network and impacts train operations. Transnet is inviting tenderers for an "as and when" contract for the repair and refurbishment of the transformers when failure occurs in service and to have them repaired promptly.

3.0 DEFINITIONS

3.1	As and when contract	Contract that allows the Contract Owner to request that the work contemplated by the contract be provided only if, and when, the work is required by the Contract Owner under pre-agreed general terms and conditions
3.2	Contract	An agreement with specific terms and conditions between two or more parties or entities based on mutual consent which has legal effects and involves transfer of consideration – usually financial or some other type of benefit.
3.3	Contract Owner	The Contract Owner is the person with the delegated authority to enter into the contract with the supplier. The Contract Owner has direct control over the applicable cost centre and the relevant approved budget.
3.4	Operational Contract Manager	Transnet employee who is authorised to represent Transnet in terms of the contract and appointed to supervise and/or liaise with the supplier to ensure that the specifications of the contract are met. This person receives the delegation from the Contract Owner to manage the contract on the latter mentioned behalf
3.5	Transformer Refurbishment	Transformer repairs, replacement of transformer parts, rewind of windings and oil purification to extend its life.

4.0 ACRONYMS

4.1	AC	Alternating Current
4.2	CT	Current Transformer
4.3	DC	Direct Current
4.4	DGA	Dissolved Gas Analysis
4.5	DP	Degree of Polymerization
4.6	FAT	Factory Acceptance Testing
4.7	FRA	Frequency Response Analysis
4.8	KVA	Kilovolt Ampere
4.9	OHTE	Overhead Track Equipment
4.10	PCB	Polychlorinated biphenyl's
4.11	SANAS	South African National Accreditation System
4.12	SAQA	South African Qualifications Authority
4.13	TFR	Transnet Freight Rail
4.14	Um	Highest phase-to phase RMS voltage for equipment

5.0 NORMATIVE REFERENCES

Unless otherwise specified all materials used, equipment developed and supplied shall comply with the latest edition of the relevant International Electro-technical Commission (IEC), International Organization for Standardization (ISO), South African National Standards (SANS) or Transnet publications.

5.1 IEC STANDARDS:

- 5.1.1 IEC 60475 Method of sampling insulating liquids

5.2 SANS STANDARD:

- 5.2.1 SANS 555 Insulating Oil for Transformers and Switchgear
- 5.2.2 SANS 780 Distribution transformers
- 5.2.3 SANS 2808 Paints and varnishes — Determination of film thickness
- SANS 60076-1 Power transformers - Part 1: General
- 5.2.4 SANS 60076-3 Power transformers - Part 3: Insulation levels, dielectric tests and external clearances in air
- 5.2.5 SANS 60076-4 Power transformers - Part 4: Guide to the lightning impulse and switching impulse testing — Power transformers and reactors
- 5.2.6 SANS 60076-18 Power transformers - Part 5: Measurement of frequency Response
- 5.2.7 SANS 60076-22-7 Power transformers - Part 22-7: Power transformer and reactor fittings — Accessories and fittings

5.3 TRANSNET PUBLICATIONS:

- 5.3.1 CEE0045 Painting of Steel Components of Electrical Equipment
- 5.3.2 BBB8204 Medium voltage transformers in accordance with SANS780
(For nominal system voltages up to 33 kV)
- 5.3.3 BBB8205 High voltage transformers in accordance with IEC 60076 and BS171
(For nominal system voltages 33 kV up to 132 kV)
- 5.3.4 BBB5019 Requirements for the traction transformers for 3 kV DC traction substations
in accordance with SANS 60076
- 5.3.5 BBF9997 10 MVA rectifier transformers for 3 kV DC traction substations in
accordance with SANS 60076
- 5.3.6 BBG2415 25kV AC Single Phase 20MVA Transformer
- 5.3.7 E4E Safety arrangements and procedural compliance with the
Occupational Health and Safety Act
- 5.3.8 E7/2 Specification for works on, over, under or adjacent to
Railway lines and near high voltage equipment

6.0 SERVICE CONDITIONS**6.1 ENVIRONMENTAL CONDITIONS**

Altitude:	0 - 1800 m above sea level
Relative humidity	10% to 90%
Ambient temperature	-10° C to +55° C`
Wind pressure	750 Pa
Lightning conditions	20 ground flashes/km ² per annum
Pollution	Heavily salt laden with industrial pollutants including diesel- electric locomotive emissions

6.2 ELECTRICAL SERVICE CONDITIONS

6.2.1 Transnet's traction and power transformers comply with the following specifications:

	Power rating	Phase system	Supply voltage	Specification number
3 kV DC traction transformers	3.5 MW – 6MW	Three phase system	33 kV to 220 kV	BBB5019
10MVA rectifier transformer for 3 kV DC traction substations	10 MW	Three phase system	33 kV to 220 kV	BBF9997
25 kV traction transformer	20 MVA	Single phase system	33 kV to 220 kV	BBG2415
6.6/11 kV high voltage distribution transformer	Up to 5 MVA	Three phase system	Up to 132 kV	BBB8205
6.6/11 kV medium voltage distribution transformer and LV step down points	Up to 3 MVA	Single and three phase	Up to 33 kV	BBB8204

7.0 ASSESSMENT OF THE FAILED TRANSFORMER

- 7.1 Any failure of a transformer in service shall initially be investigated by the responsible depot electrical engineering officer under whose jurisdiction the transformer resorts. The responsible depot electrical engineering officer shall escalate the failures to the maintenance manager of the depot. The maintenance manager shall activate Rail Network, Technical office to perform pre-liminary investigations.
- 7.2 During the pre-liminary investigation, the Rail Network, Technical Office responsible engineer shall determine the extent of damage to the transformer including any other damage to the substation equipment. Thereafter, compile the scope of work for the As and When Contract Operational Contract Manager. The Operational Contract Manager shall notify the contractor in writing about the failure of the transformer.
- 7.3 The contractor shall conduct an inspection on site, in the presence of the depot's Maintenance Manager and Rail Network, Technical Office responsible electrical engineering officer to determine the root cause of failure of the transformer and any other damage to the substation. The contractor shall submit a fault report on his findings and the extent of damage of the transformer with his recommendations as to prevent future damage to the transformer.
- 7.4 The contractor's fault report shall include full electrical and mechanical condition assessment of the transformer and Dissolved Gas Analysis (DGA) of the transformer oil, DP analysis on the insulation paper and shall make recommendation as to whether it is feasible to repair the transformer or scrap the transformer if it is not feasible to repair.
- 7.5 In the event of scrapping the transformer, the maintenance manager of the relevant depot and the Operational Contract Manager must give approval.
- 7.6 The fault report including the scope of work, transportation cost, repair cost, testing cost and repair program with the expected completion time must be submitted to the Operational Contract Manager within seven (7) working days from the time the notification was given to the contractor of the failure of the transformer.
- 7.7 The fault report shall also indicate whether repair works will be carried out on site, or the transformer will have to be transported to the contractor's workshop for repairs and routine testing.
- 7.8 The Operational Contract Manager shall authorise further action once the fault report and the repair details have been received from the contractor.

8.0 REPAIR AND REFURBISHMENT OF TRANSFORMERS

8.1 GENERAL REQUIREMENTS

- 8.1.1 The contractor shall be able to repair and refurbish TFR's traction and distribution transformers mentioned in clause 6.2.1 not covered by the OEM's warrantee.
- 8.1.2 The contractor shall be able to perform on-site and workshop repair works including tests associated with the repair works.
- 8.1.3 Only after all the electrical tests and oil analysis and commissioning have been conducted and test certificate issued can the transformer be handed over to Transnet.
- 8.1.4 The contractor shall submit a schedule of the breakdown of repair work to be done on the transformer as well any other work associated with the transformer at the substation for co-ordination purposes. Included in his schedule shall be the costs as per the schedule of prices Appendix A and a program for the repair work.
- 8.1.5 The contractor shall quote separately the labour rates for work not specified in the schedule of prices as per Appendix B and the charge rates for material not specified.
- 8.1.6 For any additional work that is discovered during the repair process, the contractor must submit a further damage report and quote for the additional work. Only after an inspection by Transnet, Rail Network, Responsible Engineering Officer shall further action be authorised in writing by

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- Transnet and the revised program for the repair will be approved. The contract must then be adjusted to the work rate agreed to.
- 8.1.7 The contractor shall arrange with the depot maintenance manager concerned to co-ordinate the site work that has to be carried out i.e., for the repair of the transformer on site or the removal thereof to transport it to the contractor's workshop.
- 8.1.8 Tenderers shall quote for:
- a. The site inspection and fault report for the failed transformer.
 - b. Site establishment (If applicable)
 - c. The draining and removal of the transformer oil from site.
 - d. The dismantling of the transformer i.e. the radiator fins, conservator tank and any other items.
 - e. The lifting and placement of the transformer on a truck for transportation to workshop.
 - f. Untanking and Inspection at the workshop for quotation of repairs.
 - g. Repair works on the transformer including replacement equipment and material cost.
 - h. All routine tests performed on the transformer. The contractor shall indicate the cost of the individual tests.
 - i. Dissolved Gas Analysis for the transformer oil.
 - j. The delivery of the transformer to site and placing it on the plinth.
 - k. The reassembling of the transformer on site.
 - l. The filling of the transformer with oil.
 - m. Commissioning and on-site testing of the transformer.
 - n. Transportation costs quoted shall either reflect the costs for transporting a load or no load or be based on daily.
- 8.1.9 The contractor must ensure that the process of drying the transformer active parts limits the deterioration of the aged insulation.
- 8.1.10 The contractor shall indicate the transformer dry-out process to be implemented and the method used to determine the desired moisture level.
- 8.1.11 All interior and exterior metal surfaces of the transformer, and associated apparatus, subject to corrosion, shall be prepared for corrosion proofing and painting in accordance with Transnet Freight Rail's Specification CEE.0045.
- 8.1.12 All external surfaces shall be finished with an acceptable outer coat colour to match the existing finish.
- 8.1.13 The conservator tank shall be painted white.
- 8.1.14 The 4-6mm, orange to green indicating silica gel with bead shape shall be used for replacement. The blue indicating silica gel containing human toxins shall not be acceptable.
- 8.1.15 All equipment shall be safely stored and protected against possible theft or damage. All equipment shall be the contractor's responsibility for the duration of the project.
- 8.1.16 After completion of project the contractor shall ensure that the site is clean and the environment is returned to its original state, any damage shall be repaired.
- 8.1.17 If there is oil spillage it shall be reported to Operational Contract Manager with details on how the spillage occurred and how the oil was contained.
- 8.1.18 The contractor shall be responsible for remedying oil spills that occur during the repair works and transportation of the oil.

8.2 SITE REPAIR WORKS

- 8.2.1 The contractor shall be responsible to supply, deliver and install all equipment, and material required to execute the work, even though not specifically referred to in this specification and shall ensure that all the necessary field test facilities, machinery, and equipment required for the successful execution of onsite repairs are available, calibrated and in working condition at all times.
- 8.2.2 Repair work of transformers on site may include the following:
- a. Bushing servicing and replacement.
 - b. Re-gasketing.
 - c. Repair of radiators, pipes and components of the cooling system.
 - d. Cleaning and painting of the outside surfaces and the fittings.
 - e. Replacement or reconditioning of transformer oil.
 - f. Dehydrating breather repair or replacement.
 - g. Conservator replacement and repairs.
 - h. Buchholz relay repair or replacement.
 - i. Winding and oil temperature indicators repairs.
 - j. Repair or replacement of transformer accessories.
 - k. LV & HV Box replacement and repairs.
 - l. All type of auxiliary parts replacement and servicing.

8.3 WORKSHOP REPAIR WORK AND TRANSPORTATION OF TRANSFORMERS

8.3.1 Dismantling, removal/placing and transportation of the transformer

- 8.3.1.1 The contractor shall be responsible for obtaining all necessary permits and approvals required to transport the transformer and ensure compliance to the National Road Traffic Act, 1996.
- 8.3.1.2 The contractor shall be responsible for dismantling the transformer, removing it from the plinth, loading it on a suitable vehicle and transporting it to the repair workshop.
- 8.3.1.3 The transformer shall be transported with the dismantled accessories. The accessories shall be adequately stored and marked.
- 8.3.1.4 Once repairs and testing has been completed at the workshop, the contractor shall be responsible for loading the transformer on vehicle, transporting it back to site and placing it on the plinth.
- 8.3.1.5 The reports generated from the electronic impact recorders used during transportation of the transformer between the workshop and the site shall be submitted to Transnet as part of the handover documents.
- 8.3.1.6 All rigging work shall only be undertaken by a qualified (trade tested and certified) rigger as per SAQA regulations.
- 8.3.1.7 All rigging equipment, mobile as well as workshops, shall be load tested and certified. The certificates shall be made available if requested.

8.3.2 Workshop repair works

- 8.3.2.1 The contractor shall be responsible to supply, deliver and install all equipment, and material required to execute the work, even though not specifically referred to in this specification and shall ensure that all the necessary test facilities, machinery, and equipment required for the successful execution of the workshop repairs are available, calibrated and in working condition at all times

8.3.2.2 Repair work of transformers in the contractor's workshop may include the following:

- a. Complete transformer rewind.
- b. Main tank replacement and repairs
- c. Replacement of the insulation of the transformer active parts.
- d. Repair or replacement of the core.
- e. Replacement of the pressure relieve valve.
- f. Sandblasting and painting of the tank, cover and conservator.
- g. Replacement of built-in CT's.
- h. Replacement or the repair of the tap changer.

8.3.2.3 In order to get rid of decomposed oil content (carbon) and sludge, the coils, core and the tank of each transformer shall be washed with suitable flushing agents.

9.0 TRANSFORMER OIL

- 9.1 The contractor shall test the oil from the transformer that has failed in service to determine the cause of failure and to ensure that the oil is not contaminated with PCB's.
- 9.2 The contractor shall drain oil from the existing transformer.
- 9.3 Contractor shall ensure that adequate oil storage capacity is available on site during the repair of transformers, in cases where oil will not be replaced or exchanged, thus be re used upon completion of refurbishment.
- 9.4 The unused (virgin) or recycled insulating oil used for filling the repaired transformer at the workshop and for topping up on site shall comply with the requirements specified in the relevant part of SANS555.
- 9.5 The contractor shall provide a SANS 555 report and full DGA and moisture analysis of the oil filled into the refurbished transformer
- 9.6 The contractor shall arrange with the Operational Contract Manager to have oil samples taken from the repaired transformer when it is delivered to site. The oil samples shall be taken by the responsible depot electrical engineering officer for tests to ensure that the oil complies to the specified requirements of SANS 555 before the transformer is energised and placed on load.
- 9.7 The method of sampling the insulating oil shall comply to IEC 60475.
- 9.8 The method statement of disposing the transformer oil shall be supplied with the oil.

10.0 TRANSFORMER BUSHINGS

- 10.1 New transformer bushings shall comply with the requirements of SANS 60137.
- 10.2 The minimum creepage distances of the new bushings shall match that of the old bushings.
- 10.3 The clearances between phase to earth and phase to phase shall be in accordance with specification SANS 60076-3.

11.0 WORKSHOP FACILITY REQUIREMENTS

- 11.1 Facility for un-tanking and disassembly should have an overhead crane and the capacity of the crane must be sufficient to lift total weight of the fully assembled transformer.
- 11.2 De-tanking of the transformer outside the workshop is not acceptable.
- 11.3 The workshop must have the following facilities
 - a. A facility for drying out the transformer active parts.
 - b. A boiler shop to repair and alteration to the tank and pipes of the transformer.
 - c. A facility to change the insulation between the transformer energised parts and the transformer metal tank.

- d. A facility to replace the insulation between windings of the transformer and between the windings and the core.
- e. A facility to repair bushings and current transformers (CT's).
- f. Acid bath for radiators to remove solid deposits.
- g. Sandblasting and respray facility.
- h. Auxiliary wiring facility.
- i. Test bay for carrying out transformer routine testing. The tenderer must indicate if transformer tests will be carried out by third party. A memorandum of understanding with the testing facilities must be furnished with tender.
- j. Core winding facility with winding machines to cater for various winding configurations. No metal works must take place in this facility.
- k. The workshop shall have oil testing facility. In the case that the tenderer outsources the services for testing of the transformer oil, a memorandum of understanding with facility must be furnished with the tender.

11.4 Tenderers must indicate any repair work or routine test that will be outsourced.

12.0 TESTING AND INSPECTIONS

- 12.1 Transnet reserves the right to be present at all tests and inspections called for in this specification.
- 12.2 The responsibility of arranging the tests called for in this specification rests with the successful tenderer.
- 12.3 A Transnet Freight Rail, Technology Management (Electrical Technology) department representative may request any additional test deemed necessary to ensure compliance.
- 12.4 All repaired or refurbished at the contractor's workshop shall undergo routine tests called for in SANS 60076-1. The routine tests shall include the following:
- a. Measurement of winding resistance.
 - b. Measurement of voltage ratio and check of phase displacement.
 - c. Measurement of short-circuit impedance and load loss.
 - d. Measurement of no-load loss and current.
 - e. Dielectric routine tests (IEC 60076-3).
 - f. Leak testing with pressure for liquid-immersed transformers (tightness test).
 - g. Check of the ratio and polarity of built-in current transformers where applicable.
 - h. Check of core and frame insulation for liquid immersed transformers with core or frame insulation.
- 12.5 Additional routine tests for transformers with $U_m > 72,5$ kV for workshop repairs
- a. Determination of capacitances windings-to-earth and between windings.
 - b. Measurement of DC insulation resistance between each winding to earth and between Windings (min 1000 MΩ).
 - c. Measurement of dissipation factor ($\tan \delta$) of the insulation system capacitances.
 - d. Measurement of dissolved gasses in dielectric liquid from each separate oil compartment except diverter switch compartment.
 - e. Measurement of no-load loss and current at 90 % and 110 % of rated voltage.
- 12.6 Tan delta/ partial discharge test on transformer bushings shall be conducted by the contractor.
- 12.7 Transnet have the right to exclude certain routine tests as part of the contractor scope based on the type of repair works performed on the faulty transformer. Such exclusions shall be subject to Technology Management (Energy and Electrical Technology) approval in writing. The contractor must indicate how the excluded tests will affect the repair warrantee.
- 12.8 Transnet and the contractor shall agree on the routine tests to be performed on a transformer that is repaired on site. The agreement shall be approved in writing by Technology Management (Energy and Electrical Technology).

- 12.9 Frequency Response Analysis (FRA) test shall be carried at the contractor workshop prior the repaired transformer is transported to site. The FRA test shall also be conducted by contractor at the site prior energising of the transformer. The results of the two FRA tests shall be compared. The test procedure shall be agreed between Transnet and the contractor.
- 12.10 Pressure test of radiators shall be performed by the contractor if applicable. The method and the pressure to be used for test shall be indicated by the contractor.
- 12.11 The measurement of paint thickness for repainted transformers shall be done in accordance with SANS 2808.
- 12.12 The contractor shall submit the internal routine test sheets three (3) days before FAT is carried out by the Transnet Freight Rail, Technology Management (Energy and Electrical Technology) department representative, witnessing the tests.
- 12.13 Final routine test reports to be submitted to the Operation Contract Manager and the forementioned TM representative after the FAT has been completed.
- 12.14 Arrangements must be made timeously with the Operational Contract Manager for the Transnet Freight Rail, Technology Management (Energy and Electrical Technology) department representative to witness and approve the tests for each transformer repaired.
- 12.15 An out of tank inspection must be arranged with Transnet, prior to putting the core and windings back into the tank.
- 12.16 An inspection certificate will be issued by Technology Management (Energy and Electrical Technology) representative to certify that material / equipment conforms to Transnet Freight Rail's requirements.
- 12.17 All measuring instruments used for the tests shall have certified, traceable accuracy and be subjected to periodic calibration, according to rules given in ISO 9001.
- 12.18 Calibration certificates issued by a recognised authority for all instruments to conduct tests on transformers shall be available for inspection, if requested by Transnet.
- 12.19 All costs for routine testing and FRA tests shall be included in the quote.

13.0 TRANSFORMER NAMEPLATES

- 13.1 The refurbished transformer shall return to site with the original OEM nameplate affixed to the tank.
- 13.2 In addition to the OEM nameplate, the contractor shall affix an additional plate with the following information:
- a. Name or trademark of the contractor.
 - b. Name or trademark of the refurbishment facility.
 - c. Date of completion of the transformer refurbishment.

14.0 TRANSFORMER HANDLING

- 14.1 The transformer shall be handled and transported using methods that will prevent the transformer from sustaining damage.
- 14.2 The transformer shall as far as possible be transported back to site filled with oil or by other best practise methods to ensure that no moisture enters the transformer tank.

15.0 SAFE WORKING ON TRANSNET SUBSTATION SITES

- 15.1 The contractor or subcontractor shall be required to work on site in accordance with Transnet's safety specification E4E and the Occupational Health and Safety Act 85 of 1993.
- 15.2 The contractor shall co-operate with the officers of Transnet and shall comply with all instructions issued and restrictions imposed with respect to the works which bear on the existence and operation of Transnet's railway lines and high-voltage equipment

- 15.3 The contractor shall co-operate with the officers of Transnet and shall comply with all instructions issued and restrictions imposed with respect to the works which bear on the existence and operation of Transnet's railway lines and high-voltage equipment as per E7/1, the specification for works on, over under or adjacent to railway lines and near high voltage equipment.
- 15.4 The contractor shall be required to work under direct supervision of Transnet appointed electrical officer on site and shall work only in the area which shall be demarcated by suitable barriers.

16.0 DOCUMENTATION REQUIREMENTS

16.1 GENERAL

- 16.1.1 Drawings and documents shall be written in English.
- 16.1.2 All units indicated in the documentation shall be in metric system.
- 16.1.3 The file containing documents and drawings should be numbered and indexed for easy identification and reference purposes.

16.2 TECHNICAL DOCUMENTS TO BE SUBMITTED BY TENDERERS:

- 16.2.1 South African National Accreditation System (SANAS) accreditation certificate for transformer testing facility conforming to ISO 17025. In a case that the certificate is not available, the tenderer shall submit a memorandum of understanding from the laboratory to be used for testing. Expiry date of the agreement shall be clearly indicated.
- 16.2.2 Brochure and/or any form of document indicating the following:
- Transformer repair services offered by the tenderer.
 - Range of transformers serviced by the tenderer.
 - Transformer refurbishment capacity of the facility per annum.
 - Indicative lead times for complete refurbishment of a 6 MW 3 kV DC traction transformer, a 20 MVA 25kV traction transformer and a 3MVA 11 kV distribution transformer.
- 16.2.3 ISO 9001 certificate. In a case that the certificate is not available, the tenderer shall submit a memorandum of understanding from the transformer repair facility to be used. Expiry date of the agreement shall be clearly indicated.
- 16.2.4 A sample of a previously compiled transformer fault/damage report. The name or trademark of the tenderer must appear in the report.

17.0 QUALITY ASSURANCE

- 17.1 The contractor shall maintain a Quality Management System (QMS) based on ISO 9001.
- 17.2 The contractor shall provide Quality Control Plans (QCP) for all transformer repair works, clearly showing all the hold points.

18.0 GUARANTEES AND DEFECTS

- 18.1 The successful tenderer shall provide all information regarding guarantee and warranties in writing. A minimum of 12 months warrantee from the date of energising shall be provided for transformer refurbishment.
- 18.2 The Operational Contract Manager shall notify the contractor in writing of the date when the transformer is energised.

END

APPENDIX A: SCHEDULE OF BREAKDOWN IN PRICES

(To be completed by the Contractor for each transformer to be repaired)

	NO OF UNITS	LABOUR PRICE	MATERIAL PRICE	TOTAL PRICE
1. Site inspection and transformer damage/fault assessment				
1.1. Call-out fee, site inspection and issuing of transformer fault/damage report				
1.2. Oil sampling and Dissolved Gas Analysis				
1.3. Diagnostic testing and mechanical assessment of transformer				
1.4. DP analysis				
2. Transformer transportation				
2.1. Without load to site				
2.2. With load to contractor workshop				
2.3. Daily rates				
2.4. Dismantling, lifting and placement of transformer on truck for transportation				
2.5. Lifting of transformer from truck, re-assembling, and placement of transformer on the plinth in the substation				
3. Strip				
3.1. Remove radiators, conservator and transformer accessories on site				
3.2. Clean parts for assessments				
3.3. Dismantle the transformer at the workshop				
4. Core, windings and tap changer				
4.1. Unstack top yolk and remove the coils				
4.2. Supply and install HV coils complete with new insulation kit				
4.3. Supply and install LV coils complete with new insulation kit				
4.4. Clean and inspect core				
4.5. Replace core				
4.6. Renew core bolts and clamp insulation				
4.7. Transformer dry out and routine IR test				
4.8. Overhaul				
4.9. Clean, inspect, overhaul tap changer				
4.10. Supply and fit new tap changer				
5. Transformer tank				
5.1. Clean and inspect tank				
5.2. Repair transformer tank				
5.3. Spray painting of transformer tank				
6. Transformer bushings				
6.1. Clean, inspect, and overhaul HV bushings				
6.2. Supply and fit new HV bushings				
6.3. Clean, inspect, and overhaul LV bushings				
6.4. Supply and fit new LV bushings				

	NO OF UNITS	LABOUR PRICE	MATERIAL PRICE	TOTAL PRICE
7. Current Transformer (CT)				
7.1. Clean, inspect and test and recondition CT's				
7.2. Supply and install new CT's				
7.3. Clean, inspect and recondition CT monoblocks				
8. Transformer accessories				
8.1. Clean, inspect, overhaul conservator				
8.2. Supply and fit new conservator				
8.3. Spray painting of conservator (White)				
8.4. Clean, inspect and overhaul oil and winding temperature gauges				
8.5. Supply and install oil and winding temperature gauges				
8.6. Clean, inspect and overhaul Buchholz relay				
8.7. Supply and install new Buchholz relay				
8.8. Supply and fill new silica gel				
8.9. Supply and install dehydrating breather				
8.10. Clean inspect and pressure test radiator				
8.11. Repair or replacement of radiators				
8.12. Fitting of valves to radiators				
9. Tanking				
9.1. Fit active parts into tank and complete all connections				
9.2. Fill transformer with unused oil tested in accordance with (SANS 555)				
9.3. Fit top complete with new gaskets and new nuts and bolts				
9.4. Auxiliary wiring				
10. Re-assembly of transformer on site				
10.1. Re-fit radiators, conservator and transformer accessories on site				
10.2. Re –assemble active part				
10.3. Final tanking of core and windings				
10.4. Final dry-out of transformers				
11. Miscellaneous				
11.1. Site establishment				
11.2. Insurance for transportation of transformers				
11.3. Preliminary and General				
11.4. Commissioning of transformer				
11.5. Nameplate				
12. Routine tests as per SANS 780 and SANS 60076, unless otherwise agreed between contractor and TFR TM				
12.1. Measurement of winding resistance				
12.2. Measurement of voltage ratio and check of phase displacement				

	NO OF UNITS	LABOUR PRICE	MATERIAL PRICE	TOTAL PRICE
12.3. Measurement of short-circuit impedance and load loss				
12.4. Measurement of no-load loss and current				
12.5. Dielectric routine tests				
12.6. Leak testing with pressure for liquid-immersed transformers				
12.7. Check of the ratio and polarity of built-in current transformers				
12.8. Check of core and frame insulation for liquid immersed transformers with core or frame insulation				
12.9. Determination of capacitances windings-to-earth and between windings ^a				
12.10. Measurement of DC insulation resistance between each winding to earth and between windings (Min 1000 MΩ) ^a				
12.11. Measurement of dissipation factor ($\tan \delta$) of the insulation system capacitances ^a				
12.12. Measurement of dissolved gases in dielectric liquid from each separate oil compartment except diverter switch compartment. ^a				
12.13. Measurement of no-load loss and current at 90 % and 110 % of rated voltage ^a				
12.14. FRA test				
13. Routine test on bushings as per SANS 60137, unless otherwise agreed between contractor and TFR TM				
13.1. (Tan delta/ partial discharge test)				

Notes: ^a only applicable for Um > 72.5 kV

Completed by:	
Capacity:	
Signature:	
Date:	

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APPENDIX B: TYPICAL RATINGS OF TRANSFORMERS IN TRANSNET SUBSTATIONS

MAKE	PRIMARY VOLTAGE	SECONDARY VOLTAGE	VECTOR GROUP	KVA
AEG	33	2*3*1365	Yyy	3340
AEG	33	2*3*1365	Dyy	3340
AEG	88	2460		6600
AEG	132	2*3*1220	Ydd±15 ⁰	4950
AEG	88	2*3*1220	Ydd±15 ⁰	4950
AEG	88	2*3*1365	Yyy	3340
AEG	88	2*3*1365	Dyy	3340
AEG	88	2*3*1365	Yyy	3340
AEG	42	2*3*1365	Yyy	3340
AEG	42	2*3*1365	Dyy	3340
AEG	132	y=6*1418,z=6*1422	Yy0/Yy6/Yz5/Yz1 1	6600
ASEA	132	2*3*1220	Ydd±15	4950
ASEA	42	2*3*1220	Ydd±15	4950
ASEA	88	2*3*1165	Ydd±15	4950
ASEA	66	2*3*1220	Ydd±15	4950
ASEA	42	2*3*1166	Yy0-Yd11	6500
ASEA	88	2*3*1220	Ydd±15	4950
ASEA	88	2*3*1165	Ydd±15	4950
ASEA	132	2*3*1165	Ydd±15	4950
ASEA	132	y=3*1418,z=3*1422	Yy0/Yy6/Yz5/Yz1 1	6600
ASEA	33	2*3*1220	Ydd±15	4950
ASEA	11	2*3*1220	Ydd±15	4950
ASEA	42	2333	Yy0	4950
BBC	88	6*2420	Dzn	3460
BBC	88	6*2420	YzN	3460
BRUCE PEEBLES	40	6*2240	Dyn	3460
BRUCE PEEBLES	33	6*2420	Dzn	5650
BRUCE PEEBLES	33	6*2420	Yzn	5650
BRUCE PEEBLES	66	6*2420	Dzn	5650
BRUCE PEEBLES	66	6*2420	Yzn	5650
BRUCE PEEBLES	20	3*2420	Dy11	4575
BRUCE PEEBLES	20	3*2420	Yy0	4575
ENGLISH	88	6*3246	Yzn	3330

ELECTRIC				
EBG	42	2*3*2450	Dyy	3360
EBG	42	2*3*2450	Yyy	3360
GEC	132	2445	Yd11y0	4800
GEC	88	2*3*1220	Yd11y0	5000
GEC	88	25000	Single phase	20000
GEC	132	25000	Single phase	20000
GEC	66	2*3*1220	Ydd±15	
GEC	132	25000		20000
HAWKER SIDDELEY	132	2*3*1220	Ydd±15	4950
JOHNSON & PHILLIPS	132	2*3*2475	Yy0d1/y0	4900
JOHNSON & PHILLIPS	88	d=3*2461,y=3*2 468	Yd1y0y0	4900
JOHNSON & PHILLIPS	82	d=3*2461,y=3*2 468	Yd1y0y0	4900
JOHNSON & PHILLIPS	42	d=3*2461,y=3*2 468	Yd1y0y0	4900
MITSHIBUSHI	132	1227	Ydy	4950
OERLIKON	132	d=3*2461,y=3*2 468	Yd1y0y0	4900
OERLIKON	88	2*3*1370	Dyy	3470
OERLIKON	88	2*3*1370	Yyy	3480
OERLIKON	132	2*3*1370	Yyy	4850
OERLIKON	82	2*3*1370	Dyy	4850
SIEMENS	88	2*3*2460	Yy0/Yd5	3400
SIEMENS	88	2445	Yy0/Yd11	4800
SOUTH WALES	132	2445	Yy0/Yd11	4800
SOUTH WALES	42	2328	Dy11	3300
SOUTH WALES	40	2328	Dy11	3300
SOUTH WALES	88	2445	Yy0/Yd11	4800
SOUTH WALES	21	2320	Yy0	3300
SOUTH WALES	21	2320	Dy11	3300
TRAFO UNION	88	2*3*1220	Yd7	4950
BONAR LONG	132	25000	Single phase	20000
ABB	132	6*1165	Yy6d5	4900
ABB	88	6*1165	Yy6d5	4900

ABB	88	25000	Single phase	20000
ABB	132	25000	Single phase	20000
BONAR LONG	88	25000	Single phase	20000
BONAR LONG	88	11000	Ydn11	3000
BONAR LONG	88	6600	Ydn11	3000
BONAR LONG	132	11000	Ydn11	3000
BONAR LONG	88	11000/6600	Ydn11	3000
ABB	88	11000	Dyn11	1000
ABB	88	11000/6600	Dyn11	1000
ABB	132	11000	Yzn11	3000