# RUSTENBURG LOCAL MUNICIPALITY

# UNIT: ELECTRICAL ENGINEERING SERVICES

# STANDARD TECHNICAL SPECIFICATIONS

# STANDARD FOR POWER TRANSFORMER REFURBISHMENT AND REPAIRS ONSITE AND OFFSITE

## INTRODUCTION

This standard applies to all transformers that are currently in use in the Rustenburg Local Municipality Electricity Distribution Network that have been earmarked for repairs/refurbishment for re-use in the Substations.

The standard provides guidelines to the Contractors and Rustenburg Local Municipality employees or any other representatives in determining the degree of repairs and refurbishment and also assists in outlining their responsibilities for power transformers ranging from 10 MVA to 40 MVA for indoor and outdoor use.

## 1 SCOPE

This standard covers the general requirements for the repairs and refurbishment of power transformers ranging from 10 MVA to 40 MVA for both indoor and outdoor use.

## 2 NORMATIVE REFERENCES

The following standards and specifications contain provisions that, through reference in the text, constitute requirements of this standard. At the time of publication the editions indicated were valid. All standards and specification are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards and specification listed below.

- South African Occupational health and safety act (as amended), Act no. 85 of 1993
- NRS 029, Current transformers for rated a.c. voltages from 36 kV up to and including 420 kV (Maximum voltage for equipment) NRS 054, Power Transformers
- NRS 079: Mineral insulating oils (uninhibited and inhibited)
- SANS 555: Unused and reclaimed mineral insulating oil for transformers and switchgear
- SANS 60076-1: Power Transformers – Part 1: General
- SANS 60076-2: Power Transformers– Part 2: Temperature rise
- SANS 60076-3: Power Transformers– Part 3: Insulation level and dielectric tests
- SANS 60076-:4: Power Transformers– Part 4: Guide to lightning impulse and switching impulse test Power transformers and reactors
- SANS 60076-5: Power Transformers– Part 5: Ability to withstand short circuit
- SANS 60076-10: Power Transformers– Part 10: Determination of sound levels
- SANS 60076-7: Power Transformers– Part 7: Loading guide for oil immersed power transformers
- SANS 60137, Insulated Bushings for alternating voltages above 1000V
- SANS 1400: Environmental systems – Requirements with guidance for use

Rustenburg Local Municipality has a preference to standardize on some of the equipment. Where applicable, the equipment has been specified as such within those specifications. Wherever the term standard is used in this specification, this shall mean the latest Rustenburg Local Municipality / international / national standard in the following order of priority:

Wherever the term goods, material and/or equipment is used it shall mean new, unused and of the most recent or current models, incorporating all recent improvements in design and materials, tested in accordance with the required standard.

## 3 DEFINITIONS AND ABBREVIATIONS

The following definitions and abbreviations in the above documents shall apply to this standard.

| | | | |
|---|---|---|---|
| 3.1 | NRS | : | National Rationalization of Specifications. |
| 3.2 | SANS | : | South African National Standards |
| 3.3 | IEC | : | International Electrotechnical Commission |
| 3.4 | IEEE | : | Institute of Electrical and Electronic Engineers Inc. |
| 3.5 | BS | : | British Standard |
| 3.6 | PCB | : | Polychlorinated biphenyl's |
| 3.7 | DGA | : | Dissolved gas analysis |
| 3.8 | FAT | : | Factory acceptance testing |
| 3.9 | SAT | : | Site acceptance testing |
| 3.10 | RLM | : | Rustenburg Local Municipality |

## 4 REQUIREMENTS

### 4.1 General

Nothing in this standard shall lessen the obligation of the supplier/contractor. The supplier/contractor shall be fully responsible for the testing, repairs and refurbishment and maintenance of the power transformer and its satisfactory performance in service. Approval by Rustenburg Local Municipality shall not relieve the supplier/contractor of the responsibility for the adequacy of the repairs and refurbishment.

The contractor shall comply fully with as much detail as possible Annexure C.3 (ON SITE MAINTANACE) of the Transformer Refurbishment Checklist and submit the report with the lead times and expected completion time of the refurbishment prior to any work commencing.

### 4.2 Service conditions

The requirements in this specification apply to transformers for use under the following general conditions described in Table 1.

| **Environment** | **Limits** |
|---|---|
| Application | Outdoors or indoors |
| Altitude | The design shall be based on an altitude of 1400 m a.m.s.l |
| Maximum ambient air temperature | Hottest any time 40 °C<br><br>Hottest monthly average 30 °C |

| | |
|---|---|
| Yearly average ambient air temperature | 20 °C |
| Minimum ambient air temperature | Coldest any time −10 °C |
| Variation in humidity | 10% to 90% |

Table 1: Atmospheric conditions

4.3 Insulation

The winding insulation shall be of a uniform nature, i.e. non-graded. The copper conductors shall be covered by thermally upgraded paper. The rating of the winding insulation shall be as described in Table 2 below.

| **Nominal Voltage (kV) Un** | **Highest Voltage (kV) Um** | **Rated short duration power-frequency voltage (kV) at 50 Hz** | **Rated peak lightning impulse withstand voltage (kV)** |
|---|---|---|---|
| 88 | 100 | 185 | 450 |
| 33 | 36 | 88 | 170 |
| 22 | 24 | 50 | 125 |
| 11 | 12 | 28 | 75 |

Table 2 – Winding insulation (based on SANS 60076-3)

4.4 Windings

4.4.1 All and any winding replacements shall be replaced with electrical grade copper with a purity of 99.9% or better.

4.4.2 The winding conductor shall be wound in a dust free environment where the atmospheric conditions (temperature and humidity) are controlled better.

4.4.3 No resin shall be used on the windings.

4.4.4 Insulated sample conductors (same insulation material used during manufacturing) shall be made and placed inside the tank during the processing and drying of the transformer. These samples may only be removed after FAT is complete, prior before the tank overpressure test is done, after the electrical part of the FAT. The paper strength shall exceed a degree of polymerisation (DP) of 1100 as per IEC 60450.

4.5 Oil

4.5.1 The Contractor shall drain oil from the existing transformer and where required provide new virgin oil for the refurbished/ repaired transformer.

4.5.2 The drained oil shall be delivered to Rustenburg Local Municipality, if not exchanged, including oil from scrapped transformers.

4.5.3 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.

4.5.4 The contractor shall provide a SANS 555 report and full DGA and moisture analysis of the bulk stored oil which will be supplied with the refurbished transformer.

4.5.5 The contractor shall provide a SANS 555 report and full DGA and moisture analysis of the oil filled into the refurbished transformer.

4.5.6 The contractor shall attach the certificate for establishment of PCB level for oils returned to Rustenburg Local Municipality.

4.6 Bushing insulators

4.6.1 Bushing insulators shall comply with the requirements of SANS 60137. Old bushings shall be tested to ensure their compliance to the standard.

4.6.2 Every bushing shall be supplied complete with an air-side bushing terminal that shall be suitable for connecting the stem to an aluminium conductor (UPAS) of diameter 26 mm and 38mm.

4.6.3 The design of insulators for 33 kV and above shall be such as to minimize corona discharge and radio interference and shall have test tappings.

4.6.4 Connections from main windings to bushing insulators shall be flexible.

4.6.5 High and low voltage bushings shall be supplied with external connectors.

4.6.6 Clamps and fittings shall be made of steel or malleable iron and shall be galvanized.

4.6.7 Bushings shall be stored in accordance with manufacturer's instructions.

4.7 On site transformer maintenance and service

4.7.1 Site establishment

This shall include staff induction, processing equipment, establishment of adequate electricity supplies, etc.

The site established shall be a clean and dry environment with temporary or permanent structures as required, a detachable roof is recommended. A positive pressure and climate conditions is a must for a clean and workable environment.

The contractor shall bring his own transformer drying equipment and heavy lifting machinery that is capable of lifting transformers sized from 10 MVA to 40 MVA respectively.

Rustenburg Local Municipality shall ensure an area 4-6 times the transformer footprint area for site establishment; the contractor shall be responsible for the soil preparation and rehabilitation of the soil and site area.

The contractor shall ensure the site is safe and necessary barricading installed when working in a live yard, ensuring both safe working conditions for the contractor and the team members while also ensuring that normal RLM's electricity operations can continues.

The contractor must have a suitable site manager with ORHVS certification on site at all times during work operations on site.

Rustenburg Local Municipality's responsible person shall provide ablution facilities and 400 V supply point for welding and testing purposes.

The Contractor shall supply Rustenburg Local Municipality with a Safety File including medical certificates and compliance certificates (working at heights, ORHVS, etc.)

4.7.2 Transformer repairs

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 and equipment required for the successful execution of onsite repairs are available and in working condition at all times. Only after electrical tests and oil analysis have been conducted and test certificate issued can the transformer be handed over to RLM's Electrical Department.

The allowable work to be done on site shall include:

1. Re-gasketing,
2. Tap changer repairs,
3. Gasket leaks sealing, Sealing of leaking gaskets
4. Oil purification [regeneration],
5. Oil replacement,
6. Oil drainage and top up and
7. Dehydrating Breather Maintenance/Service
8. Changing of Silica Gel Desiccant
9. Fans and fan motors service/maintenance and replacement
10. Oil circulation pumps and motors service/maintenance and replacement
11. Conservator inspection and Service
12. Buchholz Inspection and Service
13. Winding Temperature Indicator Test and Service
14. Oil Temperature Indicator Test and Service

All electrical testing shall be carried out in the presence of the "RLM's" Authorized representatives. All testing shall be in accordance to the IEC/SANS standards and Tests will be conducted with fully assembled Transformer with its own spares and equipment. RLM shall arrange outage requirements.

The electrical tests shall include, but not limited to the following:

1. Winding resistance test
2. Ratio test
3. Phase displacement
4. Insulation resistance
5. Polarity index (PI)
6. No load test (eddy current loss +hysteresis loss) +load losses and impedance
7. Zero Sequence Impedance (Only in YY windings)
8. Induced over voltage with partial discharged (PD) (running concurrently)
9. Capacitance and Tan delta
10. Sweep Frequency Response (SFRA)
11. Separate-source voltage Withstand test
12. Oil testing, Short temp rise at rated I (amp) (4 Hours)
13. DGA
    a. Water

b. Dielectric strength
c. Acidity
d. Colour

14. Noise level test (Acoustic)
15. Bushing tests
    a. Tan Delta
    b. PD tests
16. Build in CT's
    a. Polarity
    b. Ratio
    c. Knee Point
    d. Position where installed in winding
17. Over Pressure Test
18. Power factor on windings and bushings
19. Exciting Currents
20. Ratio
21. Impedance (Leakage Inductance)
22. DC winding resistance
23. Insulation Resistance (on core)
24. Diagnostics and Reports

These tests shall evaluate the thermal, dielectric and mechanical condition of the transformer. All tests shall be completed in a maximum period of 12 hours.

RLM's responsible person shall also carry out their own quality control tests and inspections checks and any defects noted shall be rectified by the Contractor within the agreed time frame.

### 4.7.3 Warranties

The contractor shall give Rustenburg Local Municipality a one (1) year warrantee from date of commissioning/energizing. The commissioning date to be submitted to Planned Maintenance department for monitoring.

### 4.7.4 Access to sites

The Contractor shall ensure that all necessary road clearance permits and approvals are received and that access routes to and from the site are at all times kept serviceable.

### 4.7.5 Transportation requirements

In the event where the transformer is to be moved from site [substation] to a recognized offsite maintenance facility, the Contractor shall ensure that impact recorders are installed on the unit. The impact recordings shall be logged at the commencement of the journey and at the end of the journey. These results shall accompany the transformer to its final destination and be included in the transformer test and certification documentation package that shall be submitted by the Contractor and received by RLM's responsible person at the hand-over of the unit.

The Contractor shall ensure that standard roads and transportation regulations of sensitive consignment are considered and adhered to and that the vehicle and rigging capabilities shall be of the stipulated power transformer loads (10 MVA – 40 MVA).

4.7.6 Security

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.

4.7.7 Site rehabilitation

After completion of project the Contractor shall ensure that the site is clean and returned to its original state, any building damage shall be repaired. All surplus and dismantled equipment and materials shall remain the property of RLM and shall be transported to RLM's designated site.

If there is oil spillage it shall be reported to Rustenburg Local Municipality and a detailed report on how the spillage occurred and the procedure of the removal of the oil from the soil shall be given to Rustenburg Local Municipality. The oil spill will be managed by a specialist contractor and on completion of the process to rehabilitate, the clearance certification will be submitted to Rustenburg Local Municipality for safekeeping.

4.7.8 Fans, Fan motors and pumps

All transformer cooling fans and fan motors and circulation pumps shall be properly checked for wear and tear, moisture ingress and correct rotation.

All fan motors and pumps that cannot be repaired on site shall be transported RLM stores. The integrity of all fan guards and blade screening shall be checked and secured.

4.8 Off-site [workshop] refurbishment / repairs

4.8.1 Transformer inspection and tests

The contractor shall perform a visual inspection; perform electrical tests and analysis of oil samples to prove the severity of the transformer performance. The contractor shall write a report to RLM explaining the state of the transformer, the conclusion and recommendations

RLM shall at any time carry out progress inspections to ensure that proper quality control measures are followed.

4.8.2 Dismantling, removal and transportation

RLM shall isolate, disconnect and earth the transformer and handover to the contractor. RLM shall ensure that all protection and control circuitry has been made safe and electrically disconnected, to be proved to "dead" in the presence of the appointed contractor.

The Contractor shall dismantle and remove all transformer loose parts, neatly pack on site in order to prepare the transformer for rigging out of the transformer bay (on site).

All rigging work shall only be undertaken by a qualified [trade tested and certified] rigger as per SAQA regulations.

All rigging equipment, mobile as well as workshops, shall be load tested and certified. The certificates shall be available at all times.

The Contractor shall rig and remove the transformer from the transformer bay (on site) onto a suitable vehicle, prepare the transformer and all removable and non-removable accessories for transport to RLM via the rotable process.

### 4.8.3 Workshop and testing facilities

The Contractor's repair and testing facility shall be fully equipped to repair/refurbish transformers ranging from 10 MVA to 40 MVA and have test bay facilities capable of performing all tests in accordance to the applicable IEC/SANS 60073 standards.

Workshop shall be equipped with an overhead crane with minimum lifting capacity of 100 Tons, and shall also be equipped with vapour drying out equipment which can cater for drying out of transformer ranging from 10 MVA to 40 MVA Transformers.

### 4.8.4 Storage

Storage of up to a maximum of 3-6 months after hand over shall be provided by the Contractor at his premises where after normal storage rates shall apply.

The appointed contractor shall ensure that the necessary long term storage specifications and standards are met.

RLM reserves the right to perform in location inspections from time to time of the in storage units.

### 4.8.5 Transportation to the designated site

The Contractor shall ensure that the transformer is delivered to RLM's designated site and all accessories shall be stored in crates, clearly marked and the description of each item well defined. All transformer oil openings to be tightly sealed off with 6mm [minimum] thick steel blanking plates and gaskets, Suitable sleepers (wood) shall be supplied to place the transformer onto where transformer plinth is not available.

The Contractor should also ensure that all accessories accompany the transformer to its destination, and a clearly documented audit trail provided.

Electronic Impact Recorders shall be installed when transporting the transformer from the workshop to a specified site. Pre transport sampling shall be recorded and again once offloaded at the designated site. These records are to form part of the official hand over and commissioning documentation at the end of the project.

### 4.8.6 Factory Acceptance Test

A full factory acceptance test shall be performed and shall include full oil analysis tests, SANS 555, DP paper report and transformer electrical test and mechanical tests.

Factory Acceptance Tests shall be witnessed by RLM's nominated representative. The Contractor shall inform RLM of any upcoming factory acceptance tests, in writing, two weeks prior to the proposed test dates.

Tests will be conducted with fully assembled Transformers with its own spares and equipment

The electrical tests shall include, but not limited to the following:

1. Winding resistance test
2. Ratio test
3. Phase displacement
4. Insulation resistance
5. Polarity index (PI)
6. No load test (eddy current loss +hysteresis loss) + (Load losses and Impedance)
7. Zero Sequence Impedance (Only in YY windings)
8. Induced over voltage with partial discharged (PD) (running concurrently)
9. Capacitance and Tan delta
10. SFRA (swept frequency response analysis)
11. Separate-source voltage Withstand test
12. Lightning impulse withstand Full and Chopped wave
13. Temp rise at rated I (Amp)
14. DGA
    a. Water
    b. Dielectric strength
    c. Acidity
    d. Paper insulation test report to be included if rewound was part of the scope (DP and Moisture paper)
    e. SANS 555 test to be connected for the bulk oil to be used and report submitted (IEC limits accepted)
15. Noise measurement test (acoustic)
16. Bushing tests
    a. Tan Delta
    b. PD Test
    c. Lightning Impulse Withstand
17. Build in CT's
    a. Polarity
    b. Ratio
    c. Knee Point
    d. Position where installed in winding

18. Over Pressure Test

4.8.7 Site Acceptance Test

i. A full site acceptance test shall be performed to include full oil analysis tests and full transformer electrical and mechanical tests.

ii. Site acceptance test shall be witnessed by RLM's nominated representatives.

4.8.8 Handing over

Only after electrical, mechanical tests and full oil analysis, SANS 555 and paper DP results have been conducted and test reports issued can the transformer be handed over to RLM. It shall be however noted that before final hand over RLM might also carry out their own quality control tests and inspections checks and any concerns and issues shall be reverted back to the Contractor for rectification.

4.9 Transformer handling

4.9.1 Storage

The transformers shall be restored and stored according to the Original Equipment Manufacturers (OEM) manuals.

The transformer shall be stored fully assembled and filled with oil and no gas top up shall be allowed.

The Contractor/RLM shall ensure that maintenance is done periodically, on stored transformers, according to the OEM's maintenance manual. Oil sampling and analysis shall also be performed periodically on the stored transformer to ensure there is no moisture ingress in the transformer.

4.9.2 General handling

The transformer shall only be loaded and/or off-loaded by qualified and certified riggers. The contractor shall produce proof of such qualification to RLM prior to any transformer loading and/or off-loading.

The contractor shall ensure to follow the OEM's manuals on transformer handling.

4.9.3 Environmental impact

The contractor shall perform an environmental impact assessment in the event of an oil spillage. The contractor shall provide a method statement on how the spillage shall be contained and soil/ground contamination eliminated. The contractor shall also provide a method statement on environmental rehabilitation.

The environment shall be rehabilitated and reinstated to its original state/condition subsequent to any work performed on site.

4.10 Transformer colours

The refurbished transformer colour shall comply fully to original paint before refurbishment.

Bushing turrets shall be painted according to phase colour marking and shall be clear and unobscured.

4.11 Conditions of maximum rating, temperature rises and sustained overloads

Continuous maximum rating, temperature rise and overload shall comply with SANS 60076-2 requirements and the SANS Loading Guide (SANS 60076-7) when operating with natural or forced cooling.

4.12 Duty under fault conditions

Transformers shall be capable of withstanding short circuits for the periods of time as specified in SANS 60076-5 when operating on any tap position, including that corresponding to minimum effective impedance.

4.13 Efficiency and losses

4.13.1 The efficiency and losses of each transformer shall be specified.

4.13.2 The capitalized value of each transformer's losses shall be specified.

4.14 Regulation and impedance

The voltage regulation from no load to continuous rated output at unity power factor and at 0,8 lagging power factor with constant voltage across the high voltage windings shall be as specified.

The impedance voltage between HV and LV windings at normal ratio of transformation and continuous maximum ratings shall be as specified.

4.15 Vibration and Noise

The vibration and average noise level shall be as specified in Table 1 below:

| **Equivalent two winding transformer rating [MVA]** | **Average Sound level, (dBA)** | |
|---|---|---|
| | **ONAN** | **ONAF** |
| 10 | 70 | 71 |
| 20 | 73 | 74 |
| 40 | 76 | 77 |
| **Notes: For ONAF ratings, the sound levels are with the auxiliary equipment in operation** | | |

Table 3 – Audible sound levels for oil immersed power transformers

4.16 Voltage control

4.16.1 Tap changing gear shall comply with NRS 054.

4.16.2 Transformation shall be carried out without changing phase displacement throughout the complete range of tappings.

4.16.3 The on load tap changing gear shall be provided with local hand operating gear and arranged for remote control.

4.17 Indicating devices and alarms

Temperature Indicating Devices and Alarms

4.17.1 Oil and winding temperature indicating devices shall be as specified in NRS 054. The winding temperature indicating devices shall be so designed that it shall be possible to move the pointers by hand for the purpose of checking the operation of the contacts and associated equipment.

4.17.2 The auxiliary supply shall be rated and specified

4.17.3 Gas and Oil Actuated Relays shall be as specified in NRS 054.

4.18 Marshaling kiosk, control and instrument wiring

4.18.1 These shall comply fully with NRS 054.

4.19 Current transformers

4.19.1 The current transformers shall comply fully with NRS 029, NRS 054, IEC 60044-1 and IEC 60044-2.

4.20 Surge arrestors for HV and MV

4.20.1 The surge arrestors shall comply fully with IEC 60099-4 (SANS 60099-4) and IEC 62848-1.

4.21 Multicore cables and terminal cables

4.21.1 These shall comply fully with SANS 1507 and SANS 1574.

## 5 RISK ASSESSMENT AND ENVIRONMENTAL CONDITIONS

5.1. The Contractor shall be responsible for adhering and maintaining safe, acceptable environmental management conditions on site and shall in conjunction with RLM ensure that proper oil drainage regimes are followed from date of commencement of work until work is completed and handed back over to RLM

5.2. The Contractor shall also complete a risk assessment to ensure secure and safe working conditions and submit the full SHERQ file to RLM responsible personnel.

5.3. The appointed contractor shall ensure that their responsible personnel have the necessary valid ORHVS certification for onsite works and be qualified to safely access electrical plant and equipment

## 6 WORKSHOP AND TESTING FACILITIES

6.1 Workshop Facilities

The workshop area shall be clean and dry. It shall have vertical winding lathes and an overhead crane with a loading of not less than 100 tons. The rewind and tanking area shall be dust free and under positive pressure. Vapour phase process capabilities are essential.

6.2 Testing Facilities

The workshop testing facilities shall be accredited by SANAS or equivalent body. The facility shall be ISO 9001 and 14001 accredited.

## 7 TESTS

The following tests shall be performed on refurbished transformers

7.1. Winding resistance test
7.2. Ratio test
7.3. Phase displacement
7.4. Insulation resistance
7.5. Polarity index (PI)
7.6. No load tests (eddy current loss and hysteresis loss)
7.7. Zero phase impedance
7.8. Induced over voltage
7.9. Capacitance and tan delta
7.10. Swept frequency response analysis (SFRA)
7.11. Separate-source voltage withstand test
7.12. Lightning Impulse
7.13. Noise level measurement (acoustic)
7.14. Full DGA and moisture test

## 8 TRANSFORMER CHECKLIST

Once a decision to repair/refurbish has been taken, Rustenburg Local Municipality in conjunction with the Contractor shall verify the transformer parts and their condition before any refurbishment/repair is undertaken using a form in Annexure C1. This form shall then be given to the Contractor and copies shall be given to the following departments:

1. Planning
2. Asset Management
3. Engineering Workshop (transformer bay)
4. Field Services Primary Plant and
5. Field Services Secondary Plant
6. Technology Services (Primary Plant)
7. Planned Maintenance.

All the transformer parts shall accompany the transformer to its designated site and shall be the Contractor's responsibility for the duration of the project.

## 9 DOCUMENTATION

9.1. A copy of all Factory Acceptance Test reports shall be provided.
9.2. A copy of all Site Acceptance Test reports shall be provided.
9.3. A copy of the warrantee period and agreement
9.4. Impact recordings.
9.5. Dry-keep and DGA service and calibration certificates.

## 10 WARANTEE PERIOD

A written one-year warrantee based from time of energizing for all refurbished transformers shall be provided.

## 11 HANDING OVER

Refurbished transformer shall only be accepted by RLM after the site acceptance test proves it complies with RLM specification and checklists.

## 12 QUALITY ASSURANCE

A quality management system shall be set up in order to assure the quality of power transformers during design, development, production, installation and servicing. Guidance on the requirements for a quality management system may be found in the following standards: ISO 9001. The details shall be subject to agreement between the purchaser and supplier.

## 13 ENVIRONMENTAL MANAGEMENT

An environmental management system shall be set up in order to assure the environmental compliance of the power transformers throughout its entire life cycle (i.e. during design, development, production, installation, operation and maintenance, decommissioning and disposal phases). Guidance on the requirements for an environmental management system may be found in SANS 14001. The details shall be subject to agreement between the purchaser and supplier.

## 14 HEALTH AND SAFETY

A health and safety plan shall be set up in order to ensure proper management of transformer repairs and refurbishment onsite or at contractor's workshop and compliance of the queuing system during installation, operation, maintenance, and decommissioning phases. Guidance on the requirements of a health and safety plan may be found in OHSAS 18001 standards. This is to ensure that the asset conforms to standard operating procedures and RLM SHERQ Policy. The details shall be subject to agreement between RLM and the Supplier.

**STANDARD FOR POWER TRANSFORMER REFURBISHMENT AND REPAIRS ONSITE AND OFFSITE**

**ANNEXURE A: COMPLIANCE CHECKLIST**

A.1: TRANSFORMER ASSESSMENT

| Item | Description of the job | Yes / No | Comments |
|---|---|---|---|
| **1** | **Site Establishment** | | |
| 1.1 | Establish site according to sub – clause 4.7.1 of this document | | |
| **2** | **Transport and Rigging** | | |
| 2.1 | Hydraulic crane truck hire 0 – 100 tons | | |
| 2.2 | Hydraulic crane truck 50 – 300 tons with boom height of 50m | | |
| 2.3 | Transformer rigging using jacking system ( 0 – 100tons) | | |
| 2.4 | Transformer rigging using a crane ( 0 – 100tons) | | |
| 2.5 | Remove existing unit from site 0 – 100 tons | | |
| 2.6 | Remove existing unit from site 20 – 40 tons | | |
| 2.7 | Remove existing unit from site 40 – 60 tons | | |
| 2.8 | Remove existing unit from site 60 – 80 tons | | |
| 2.9 | Remove existing unit from site 80 – 100 tons | | |
| 2.1 | Transport of transformer to workshop (per km) | | |
| 2.11 | Offload transformer at workshop facilities | | |
| **3** | **Inspections and Analysis - Active Part** | | |
| 3.1 | Untank active parts and assess | | |
| 3.2 | Conduct preliminary test on transformer active parts | | |
| 3.3 | Conduct Full oil analysis (DGA; Water, kV and acidity) | | |
| 3.4 | Conduct DP analysis on the paper | | |
| **4** | **Inspections and Analysis – Tank** | | |
| 4.1 | Inspect tank | | |
| 4.2 | Inspect all motors and coolers | | |
| 4.3 | Inspect all pressure relief devices | | |
| 4.4 | Inspect conservator | | |
| 4.5 | Inspect all valves and piping | | |

| Item | Description of the job | Yes / No | Comments |
|---|---|---|---|
| **5** | **Bushings** | | |
| 5.1 | Conduct preliminary tests on all bushings. For condenser type bushings, Tan Delta/Partial Discharge test are required (issue test certificate) | | |
| 5.2 | Take oil samples from bushings and have them analysed (with supervision from Rustenburg Local Municipality) | | |
| 5.3 | Drain oil, dismantle and inspect all the bushings | | |
| **6** | **On-load tap changer (Box-type)** | | |
| 6.1 | Open front cover and inspect the defects | | |
| 6.2 | Remove all contact epoxy boards and inspect for cracks or any other defects | | |
| 6.3 | Remove barrier boards and inspects for cracks and effects | | |
| 6.4 | Inspect pressure relays for defects and check settings | | |
| 6.5 | Inspect mechanical drive mechanism for defects | | |
| 6.6 | Record transitional resistor value and compare with the name plate information where applicable | | |
| 6.7 | Inspect all contacts and shafts for wear and defects | | |
| **7** | **On-load tap changer (Cylinder-type)** | | |
| 7.1 | Open and drain oil from the diverter switch | | |
| 7.2 | Dismantle and untank the diverter switch | | |
| 7.3 | Inspect, test and overhaul diverter switch | | |
| 7.4 | Replace all faulty parts | | |
| 7.5 | Test the diverter tube for leaks | | |
| **8** | **Reporting** | | |
| 8.1 | Supply full detailed report and recommendations | | |
| 8.2 | Scrap copper price must be provided and indicated as a savings | | |

Tender Number: _____

Tenderer's Authorized Signatory: _____ _____
Name and Surname Signature

Name of Company: _____

A.1: ADDITIONAL ACTIVITIES

| **Any additional activities offered to the above checklist shall be listed below with reasons for addition.** | | | |
|---|---|---|---|
| **Item** | **Description of the job** | **Yes / No** | **Comments** |
| | | | |
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Tender Number: _____

Tenderer's Authorized Signatory: _____ _____
Name and Surname Signature

Name of Company: _____

A.2: FACTORY REPAIRS / REFURBISHMENT

| Item | Description of the job | Yes / No | Comments |
|---|---|---|---|
| **1** | **Site Establishment** | | |
| 1.1 | Establish site according to sub – clause 4.7.1 of this document. | | |
| **2** | **Active parts** | | |
| 2.1 | Untank active parts and assess | | |
| 2.2 | Conduct preliminary test on transformer active parts | | |
| 2.3 | Dismantle yoke and remove faulty windings | | |
| 2.4 | Check , clean and overhaul core | | |
| 2.5 | Renew core bolt and clamp insulation as required | | |
| 2.6 | Strip and rewind all coils using new bright annealed high conductivity copper covered with Kraft paper. (Provide DP results for the paper – certificate) before and after processing | | |
| 2.7 | Conduct preliminary test on new coils | | |
| 2.8 | Pre-press winding(s) to specification | | |
| 2.9 | Reassemble and dry core and windings | | |
| 2.10 | Conduct pre-test to ensure correct ratios and resistances | | |
| 2.11 | Fit and tape harnessing for final dry-out | | |
| **3** | **Tank and parts** | | |
| 3.1 | Drain oil from tank and clean and inspect tank. | | |
| 3.2 | Overhaul and re-gasket tank and parts (valves, pumps, inspection plate, coolers etc.) | | |
| 3.3 | Overhaul and pressure test all coolers (issue test certificate) | | |
| 3.4 | Overhaul cooling motors and fans (issue test certificate) | | |
| 3.5 | Overhaul, test and fit Buchholz relay (issue test certificate) | | |
| 3.6 | Service all pressure devices, supply and fit new micro switches to all of them (issue test certificate) | | |
| 3.7 | Inspect, clean and test all associated cable work | | |
| 3.8 | Overhaul, re-gasket and replace all seals on conservator gauges and conservator tank | | |
| 3.9 | Check and service conservator bag | | |

| Item | Description of the job | Yes / No | Comments |
|---|---|---|---|
| **4** | **Bushings** | | |
| 4.1 | Conduct preliminary tests on all bushings. For condenser type bushings, Tan Delta/Partial Discharge test are required (issue test certificate) | | |
| 4.2 | Take oil samples from bushings and have them analysed (with supervision from Rustenburg Local Municipality) | | |
| 4.3 | Drain oil, dismantle and inspect all the bushings | | |
| 4.4 | Replace seals and gaskets | | |
| 4.5 | Assemble and fill with oil (SANS 555 Certificate for the oil used must be issued) | | |
| 4.6 | Final test of bushings (issue test certificates) | | |
| **5** | **On-load tap changer (Box-type)** | | |
| 5.1 | Open front cover and inspect the defects | | |
| 5.2 | Remove all contact epoxy boards and inspect for cracks or any other defects | | |
| 5.3 | Remove barrier boards and inspects for cracks and effects | | |
| 5.4 | Inspect pressure relays for defects and check settings | | |
| 5.5 | Inspect mechanical drive mechanism for defects | | |
| 5.6 | Record transitional resistor value and compare with the name plate information where applicable | | |
| 5.7 | Inspect all contacts and shafts for wear and defects | | |
| **6** | **On-load tap changer (Cylinder-type)** | | |
| 6.1 | Open and drain oil from the diverter switch | | |
| 6.2 | Dismantle and untank the diverter switch | | |
| 6.3 | Inspect, test and overhaul diverter switch | | |
| 6.4 | Replace all faulty parts | | |
| 6.5 | Test the diverter tube for leaks | | |
| 6.6 | On-load tap changer (Box-type) | | |
| **7** | **Open front cover and inspect the defects** | | |
| 7.1 | Remove all contact epoxy boards and inspect for cracks or any other defects | | |
| 7.2 | Remove barrier boards and inspects for cracks and effects | | |
| 7.3 | Inspect pressure relays for defects and check settings | | |

| Item | Description of job | Yes / No | Comments |
|---|---|---|---|
| 7.4 | Inspect mechanical drive mechanism for defects | | |
| **8** | **Final Assembly** | | |
| 8.1 | Check and tighten all parts of the active parts and final tank | | |
| 8.2 | Draw vacuum | | |
| 8.3 | Break the vacuum and test fit all parts {bushings. tap changer (box type) | | |
| 8.4 | and ancillary parts} | | |
| 8.5 | Draw vacuum and fill transformer with oil | | |
| **9** | **Test transformer as per SANS 60076 (part 1,2,3,4,5 and 10) included tests are as follows:** | | |
| 9.1 | Induced over voltage | | |
| | a) Separate source over potential | | |
| | b) No-load | | |
| | c) Load losses and impedance voltage | | |
| | d) No load loss [Copper and Iron losses] | | |
| | e) Cellulose moisture content | | |
| | f) Insulation resistance | | |
| | g) Winding resistance | | |
| | h) Voltage/Turns ratio and Phase displacement | | |
| | i) Zero phase Impedance | | |
| | j) Transformer Tan Delta and Capacitance | | |
| | k) Magnetising current | | |
| | l) Core ground insulation | | |
| 9.2 | Drain oil and prepare auxiliary parts for spray painting with original paint | | |
| 9.3 | Wait to dry and load transformer and parts for transport to site | | |
| **10** | **Transport and Rigging** | | |
| 10.1 | Install unit at selected site: 0 – 20 tons | | |
| 10.2 | Install unit at selected site: 20 – 40 tons | | |

| Item | Description of job | Yes / No | Comments |
|---|---|---|---|
| 10.3 | Install unit at selected site: 40 – 60 tons | | |
| 10.4 | Install unit at selected site: 60 – 80 tons | | |
| 10.5 | Install unit at selected site: 80 – 100 tons | | |
| 10.6 | Transport of transformer to site (per km) | | |
| 10.7 | Offload transformer at site | | |
| **11** | **On – site activities** | | |
| 11.1 | Draw a vacuum for 48 hours | | |
| 11.2 | Supply virgin oil (per litre) (SANS 555 oil certificate) | | |
| 11.3 | Fill oil under vacuum | | |

Tender Number: _____

Tenderer's Authorized Signatory: _____ _____
Name and Surname Signature

Name of Company: _____

A.2: ADDITIONAL ACTIVITIES

| Any additional activities offered to the above checklist shall be listed below with reasons for addition. | | | |
|---|---|---|---|
| **Item** | **Description of the job** | **Yes / No** | **Comments** |
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Tender Number: _____

Tenderer's Authorized Signatory: _____ _____
Name and Surname Signature

Name of Company: _____

A.3: ONSITE MAINTENANCE

| Item | Description of job | Yes / No | Comment |
|---|---|---|---|
| 1 | Onsite risk and condition assessment | | |
| 2 | High pressure wash the transformer to remove all oil and dirt from the transformer as well as the plinth | | |
| 3 | Re-gasketing of main tank | | |
| 4 | Re-gasketing of bushings | | |
| 5 | Remove and Install new bushings where required | | |
| 6 | Re-gasketing of tap changer chamber | | |
| 7 | Tap changer service/maintenance | | |
| 8 | Oil purification [regeneration] | | |
| 9 | Oil drainage and top up | | |
| 10 | Radiator fins inspection and maintenance | | |
| 11 | Dehydrating Breather Maintenance/Service | | |
| 12 | Changing of Silica Gel Desiccant | | |
| 13 | Fans and fan motors service/maintenance and ensure correct rotation | | |
| 14 | Remove old and install new fans where required | | |
| 15 | Remove old and install new fan motors where required | | |
| 16 | Oil circulation pumps and motors service/maintenance | | |
| 17 | Remove old and install new oil circulation pumps where required | | |
| 18 | Conservator inspection and Service | | |
| 19 | Buchholz Inspection and Service | | |
| 20 | Winding Temperature Indicator Service and test | | |
| 21 | Test, calibrate and adjust the indicators | | |
| 22 | Oil Temperature Indicator Test and Service | | |
| 23 | Spray paint the whole transformer | | |
| 24 | Paint the bushings to match the phases | | |
| 25 | Installation of drain valves where required | | |

| Item | Description of job | Yes / No | Comments |
|---|---|---|---|
| 26 | Service, test and calibrate the thermometers | | |
| 27 | Service, test and calibrate winding temperature indicators | | |
| 28 | Remove old OTI and replace with new OTI where required | | |
| 29 | Remove old WTI and replace with new WTI where required | | |
| 30 | Remove old buchollz and replace with new buchollz where required | | |
| 31 | Test Internal neutral CT where applicable | | |
| 32 | Service and test magnetic type oil level gauge | | |
| 33 | Remove old and replace with new magnetic type oil gauge where required | | |
| 34 | Supply and install new HV surge arrestor brackets where required | | |
| 35 | Supply and install new MV surge arrestor brackets where required | | |
| 36 | Supply and Install new HV surge arrestors | | |
| 37 | Supply and install new MV surge arrestors | | |
| 38 | | | |
| 39 | | | |
| 40 | Remove contaminated crusher stones and replace with new where required | | |
| 41 | Maintenance of the aux/NEC/NEC transformer | | |
| 42 | Remove faulty (old) NEC/NER and install and commission new NEC/NER | | |
| 43 | Winding Resistance Test | | |
| 44 | Transformer Turns Ratio Test | | |
| 45 | Phase Displacement | | |
| 46 | Insulation Resistance Test | | |

| Item | Description of job | Yes / No | Comments |
|---|---|---|---|
| 47 | Polarity Index (PI) | | |
| 48 | No load losses test | | |
| 49 | Full load losses | | |
| 50 | Zero sequence impedance | | |
| 51 | Induced overvoltage with partial discharge | | |
| 52 | Tan Delta Test | | |
| 53 | Transformer Oil Break Down Test | | |
| 54 | Magnetic Balance Test | | |
| 55 | Draw routine oil sample | | |
| 56 | Dissolve Gas Analysis (DGA) | | |

Tender Number: _____

Tenderer's Authorized Signatory: _____ _____
Name and Surname Signature

Name of Company: _____

A.3: ADDITIONAL ACTIVITIES

| Any additional activities offered to the above checklist shall be listed below with reasons for addition. | | | |
|---|---|---|---|
| **Item** | **Description of the job** | **Yes / No** | **Comments** |
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A.4: WORKSHOP TRANSFORMER REPAIRS/REFURBISHMENT

| Item | Description of the job | Yes / No | Comments |
|---|---|---|---|
| **1** | **Site Establishment** | | |
| 1.1 | Allow for complying with all General and Special Conditions of Contract, labour requirements, site establishment , water and sanitary facilities, first aid services, electrical services | | |
| 1.2 | Allow for the storage and safe keeping of all materials and equipment including the provision of insurances as stipulated in the Conditions of Contract. Allow for 24 hour security for the duration of the contract. | | |
| 1.3 | Allow for marking-up a full set of drawings to show the exact positions of cables, transformer earthing etc. These "As Built" drawings must be handed to the engineer at commissioning of the equipment. Also all maintenance manuals, including all technical literature, test certificates and wiring diagrams as per specification. | | |
| 1.4 | Allow for marking-up a full set of drawings to show the exact positions of cables, transformer earthing etc. These "As Built" drawings must be handed to the engineer at commissioning of the equipment. Also all maintenance manuals, including all technical literature, test certificates and wiring diagrams as per specification. | | |
| 1.5 | Allow for training for Rustenburg Local Municipality staff during installation and commissioning of complete installation. | | |
| 1.6 | Any additional item(s), not shown in the schedules that the tenderer consider essential and wish to detail and price. (Provide full details) | | |
| **2** | **Onsite maintenance** | | |
| | Complete as per ANNEXURE A3 | | |
| **3** | **Final assembly** | | |
| | Complete as per ANNEXURE A2: part 2,3,4,5,6,7,8 | | |
| **4** | **Transformer tests** | | |
| | Complete as per ANNEXURE A2: 9 | | |
| 4.1 | Remove paper sample and test for DP | | |
| 4.2 | Draw oil for SANS 555 report from bulk | | |
| 4.3 | Draw oil sample for full DGA, moisture and kV report | | |

| Item | Description of job | Yes / No | Comments |
|---|---|---|---|
| **5** | **Transport to site and offload** | | |
| 5.1 | Transport of transformer to site (per km) | | |
| 5.2 | Offload transformer at site | | |
| **6** | **Rigging and installation** | | |
| 6.1 | Provide malthoid on plinth where required | | |
| 6.2 | Install unit at selected site: 0 – 40 tons | | |
| 6.3 | Install unit at selected site: 41 – 80 tons | | |
| 6.4 | Install unit at selected site: 81 – 100 tons | | |
| **7** | **Tank and parts** | | |
| | Complete as per ANNEXURE A2: part 3 | | |
| **8** | **Auxillaries** | | |
| 8.1 | Supply new silica gel breather where applicable | | |
| 8.2 | Check and replace pressure relief devices | | |
| 8.3 | Check and service Dry-Keep unit where required | | |
| 8.4 | Check and test transformer protection indicators | | |
| **9** | **On site activities** | | |
| 9.1 | Drain oil and prepare auxiliary parts for spray painting with original paint | | |
| 9.2 | Wait to dry and load transformer and parts for transport to site | | |
| 9.3 | Draw a vacuum for 48 hours | | |
| 9.4 | Supply virgin oil (per litre) where applicable | | |
| 9.5 | Fill oil under vacuum | | |
| 9.6 | Connect the HV and MV bushings | | |
| 9.7 | HV Busbar/Conductor Clamps | | |
| 9.8 | HV Conductor (Centipede) where required | | |
| 9.9 | HV Conductor (Hare) to Surge Arrestors | | |
| 9.10 | Solid Copper Busbar 160mm x 12mm between MV TX bushing and cable termination | | |
| 9.11 | Flexible clamp for Solid Copper Busbar 160mm x 12mm onto MV bushing | | |

| Item | Description of the job | Yes / No | Comments |
|---|---|---|---|
| 9.12 | Provide MV Busbar/Conductor Clamps where required | | |
| 9.13 | Tubular Aluminium busbar clamps (inclusive of end cap on one side) | | |
| 9.14 | MV Conductor (Bull) | | |
| 9.15 | Supply, Install surge arrestors brackets where required | | |
| 9.16 | Connect the auxilliary wiring to the marshalling kiosk | | |
| 9.17 | Connect the NECR/Aux transformer and transformer earth lead | | |
| 9.18 | Remove existing plinth | | |
| 9.19 | Install new concrete plinth (25MPA) | | |
| 9.2 | Remove existing marshalling kiosk | | |
| 9.21 | Remove existing termination structure | | |
| 9.22 | Supply & install complete cable support structure for cable terminations & cable supports. Required foundations, bolts, nuts, indication signage and earthing to be included | | |
| 9.23 | Corrosion protection paint to steel | | |
| 9.24 | Supply and install galvanized holding down bolts for steel structures | | |
| 9.25 | Install new removable barrier welded mesh fence with frame | | |
| 9.26 | 70mm² CCS conductor and connect onto main earth grid using exothermic welding only | | |
| 9.27 | Test and verify earthmat integrity | | |
| 9.28 | Control and Low Voltage cables where required | | |
| **10** | **Adhoc purchases** | | |
| 10.1 | 7 Core - 2.5mm² | | |
| 10.2 | 12 Core - 2.5mm² | | |
| 10.3 | 4 Core - 2.5mm² | | |
| 10.4 | 4 Core - 16mm² | | |
| 10.5 | 4 Core - 4mm² | | |
| 10.6 | 19 Core - 2.5mm² | | |
| 10.7 | 4 Core - 1.5mm² (screened) | | |
| 10.8 | Cable racking - 300mm wide | | |
| 10.9 | 7 Core - 2.5mm² termination | | |

| Item | Description | Yes / No | Comments |
|---|---|---|---|
| 10.10 | 12 Core - 2.5mm² termination | | |
| 10.11 | 4 Core - 2.5mm² termination | | |
| 10.12 | 4 Core - 16mm² termination | | |
| 10.13 | 4 Core - 4mm² termination | | |
| 10.14 | 19 Core - 2.5mm² termination | | |
| 10.15 | 4 Core - 1.5mm² termination | | |
| 10.16 | Verification of all control and protection circuits and as the supply of as-built drawings | | |
| 10.17 | Terminate 500 mm² x 1c Cu Cable | | |
| 10.18 | Joint 500mm² x 1c Cu Cable | | |
| **11** | **On site Testing** | | |
| | Electrical Test to be performed | | |
| 11.1 | a) Induced over voltage | | |
| | b) Separate source over potential | | |
| | c) No-load | | |
| | d) Load losses and impedance voltage | | |
| | e) No load loss [Copper and Iron losses] | | |
| | f) Cellulose moisture content | | |
| | g) Insulation resistance | | |
| | h) Winding resistance | | |
| | i) Voltage/Turns ratio and Phase displacement | | |
| | j) Zero phase Impedance | | |
| | k) Transformer Tan Delta and Capacitance | | |
| | l) Magnetising current | | |
| | m) Noise level test | | |
| | n) Core ground insulation | | |
| 11.2 | Draw oil sample for DGA report | | |
| **12** | **Liven up and Handover to Rustenburg Local Municipality** | | |

Tender Number: _____

Tenderer's Authorized Signatory: _____ _____
Name and Surname Signature

Name of Company: _____

A.4: ADDITIONAL ACTIVITIES

| Any additional activities offered to the above checklist shall be listed below with reasons for addition. | | | |
|---|---|---|---|
| **Item** | **Description of the job** | **Yes / No** | **Comments** |
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