



TITLE	<b>SPECIFICATION FOR POST-TYPE CIRCUIT BREAKER UP TO 132 kV</b>	REFERENCE <b>CP_TSSPEC_145</b>	REV <b>0</b>
		DATE:	<b>NOVEMBER 2005</b>
		PAGE:	<b>1 OF 67</b>
		REVISION DATE:	<b>OCTOBER 2007</b>

COMPILED BY	FUNCTIONAL RESP	APPROVED BY	AUTHORIZED BY
			
<b>S J THOBEJANE</b> ENGINEER / TECHNICIAN: SUBSTATIONS	<b>S A NTLATLENG</b> STUDY COMMITTEE CHAIRMAN : TRANSMISSION AND GENERATION	<b>M ALLY</b> MANAGER : TECHNOLOGY SERVICES	<b>S ZIMU</b> VICE PRESIDENT : OPERATIONS

## TABLE OF CONTENTS

	Page
FOREWORD.....	3
INTRODUCTION .....	3
1 SCOPE .....	3
2 NORMATIVE REFERENCES .....	3
3 DEFINITIONS AND ABBREVIATIONS .....	3
4 REQUIREMENTS .....	3
4.1 Circuit-breaker description .....	3
4.2 Characteristics and performance .....	3
4.3 Design and construction .....	3
4.4 Maintenance considerations .....	3
4.5 Erection .....	3
4.6 Operation .....	3
4.7 Maintenance information .....	3
4.8 Instruction manuals .....	3
4.9 Maintenance videotape or DVD .....	3
4.10 Spares .....	3
4.11 Maintenance training .....	3
4.12 Maintenance contract .....	3
4.13 Drawings .....	3
5 INSPECTION AND TESTS .....	3
5.1 Type testing .....	3
5.2 Routine testing .....	3
5.3 Pre-commissioning tests .....	3
Annex A – Bibliography .....	3

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**2**

OF

**67**

-----

**Annex B – Revision information.....37**  
**Annex C – Technical schedules A and B.....38**  
**Annex D – Stock Items .....67**

**FOREWORD**

This specification was prepared by a Working Group comprising the following members:

S.J. Thobejane (Chairman)	Technology Services
S.A. Ntlatleng	Technology Services
N.R. Pema	Technology Services
Y. Seedat	Capital Planning
C. Odendaal	Maintenance Execution
N. Thwala	Power System Protection
W. Harper	Power System Protection
P. Vermeulen	SCADA
S. B. Khumalo	SCADA
K. Lumley	Central Support
D. Steyn	Central Support

The Work Group was appointed by the Transmission and Generation Study Committee, which, at the time of approval, comprised of the following members:

S.A. Ntlatleng (Chairman)	Technology Services
M. Ally	Technology Services
C. Odendaal	Power Systems Maintenance
D. Pedder	Central Support
G. Olivier	Planning Services
J. Thobejane	Technology Services
M. Walter	Power System Control
M. Ryan	Technology Services
N. Pema	Technology Services
K. Lumley	Central Support
P. Radebe	SHER
L. Magida	Energy Management
S.B. Khumalo	Power System SCADA
T. Nicholls	Power System Maintenance
X. Lembede	Planning Services
Y. Seedat	Planning Services
N. Thwala	Power System Protection
Z. Phoku	SHER

Recommendations for corrections, additions or deletions should be addressed to the:

Technology Services Manager  
City Power Johannesburg (Pty) Ltd  
P O Box 38766  
Booyens  
2016

---

## **INTRODUCTION**

This specification details City Power's specific and standardized requirements for post-type vacuum and SF6 circuit breakers, in accordance with IEC 62271-100.

## **1 SCOPE**

This specification covers City Power's requirements for high-voltage, alternating-current circuit breakers for voltages of 33 kV up to and including 132 kV. The specification covers the design, manufacture, fabrication, testing, supply, delivery and guarantee of live-tank, three-phase circuit-breakers and associated equipment.

The circuit-breakers shall be supplied together with all auxiliary equipment necessary for a complete installation.

## **2 NORMATIVE REFERENCES**

IEC 60034: *Rotating electrical machines*

IEC 60038: *IEC standard voltages*

IEC 60050-151: *International Electrotechnical Vocabulary Chapter 151 Electrical and magnetic devices*

IEC 60050-191: *International Electrotechnical Vocabulary Chapter 191 Dependability and quality of service*

IEC 60050-441: *International Electrotechnical Vocabulary Chapter 441 Switchgear, control-gear and fuses*

IEC 60050-601: *International Electrotechnical Vocabulary Chapter 601 Generation, transmission and distribution of electricity — General*

IEC 60050-604: *International Electrotechnical Vocabulary Chapter 604 Generation, transmission and distribution of electricity — Operation*

IEC 60059: *IEC standard current ratings*

IEC 60060-1: *High-voltage test techniques — Part 1. General definitions and test requirements.*

IEC 600137: *Insulated bushings for alternating voltages above 1 000 V*

IEC 60158-1: *Low-voltage control-gear — Part 1: Contractors*

IEC 60168: *Tests on indoor and outdoor post insulators of ceramic material or glass for systems with nominal voltages greater than 1 000 V*

IEC 62271-100: *High-voltage switchgear and controlgear: Part 100 – High-voltage alternating-current circuit-breakers*

IEC 60233: *Tests on hollow insulators for use in electrical equipment*

IEC 60267: *Guide to the testing of circuit-breakers with respect to out-of-phase switching*

IEC 60270: *Partial discharge measurements*

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**5**

OF

**67**

-----  
IEC 60273: *Characteristics of indoor and outdoor post insulators for systems with nominal voltages greater than 1 000 V*

IEC 60376, 197: *Specification and acceptance of new sulphur hexafluoride*

IEC 60417: *Graphical symbols for use on equipment. Index, survey and compilation of the single sheets.*

IEC 60427: *Synthetic testing of high-voltage alternating current circuit-breakers. Amendment No 1 (1992).*

IEC 60480: *Guide to the checking of sulphur hexafluoride (SF<sub>6</sub>) taken from electrical equipment*

IEC 60518: *Dimensional standardisation of terminals for high-voltage switchgear and control-gear*

IEC 60529: *Degrees of protection provided by enclosures (IP code)*

IEC 60632-1: *High-voltage motor starters — Part 1 Direct on-line (full voltage) AC starters.*

IEC 60694: *Common clauses for high-voltage switchgear and control-gear standards.*

*Amendment No 1 (1995). Amendment No. 2 (1993).*

IEC 60715: *Dimensions of low-voltage switchgear and control-gear. Standardised mounting on rails for mechanical support of electrical devices in switchgear and control-gear installations.*

IEC 60721-2-2: *Classification of environmental conditions — Part 2 Environmental conditions appearing in nature. Precipitation and wind.*

IEC 60721-2-4: *Classification of environmental conditions. — Part 2 Environmental conditions appearing in nature. Solar radiation and temperature. Amendment No 1 (1988).*

*SANS IEC 60815: Guide for the selection of insulators in respect of polluted conditions*

IEC 60890: *A method of temperature-rise assessment by extrapolation for partially type-tested assemblies (PTTA) of low-voltage switchgear and control-gear.*

IEC 60932: *Additional requirements for enclosed switchgear and control-gear from 1 kV to 72,5 kV to be used in severe climatic conditions.*

IEC 60947-1: *Low-voltage switchgear and control-gear — Part 1: General rules*

IEC 60947-2: *Low-voltage switchgear and control-gear — Part 2: Circuit-breakers.*

*Amendment No 1 (1992)*

IEC 60947-3: *Low-voltage switchgear and control-gear — Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units.*

IEC 60947-4-1: *Low-voltage switchgear and control-gear — Part 4: Contactors and motor starters – Section One: Electromechanical contactors and motor-starters.*

IEC 60947-5-1: *Low-voltage switchgear and control-gear — Part 5: Control circuit devices and switching elements - Section One: Electromechanical control circuit devices.*

IEC 60947-5-2: *Low-voltage switchgear and control-gear — Part 5: Control circuit devices and switching elements – Section 2: Proximity switches.*

IEC 60947-6-1: *Low-voltage switchgear and control-gear. — Part 6: Multiple function equipment – Section One: Automatic transfer switching equipment*

-----  
IEC 60947-6-2: *Low-voltage switchgear and control-gear — Part 6: Multiple function equipment - Section Two: Control and protective switching devices (or equipment) (CPS).*

IEC 60947-7-1: *Low-voltage switchgear and control-gear — Part 7: Ancillary equipment – Section One: Terminal blocks for copper conductors.*

IEC 61166: *High-voltage alternating-current circuit-breakers — Guide for seismic qualification of high-voltage alternating-current circuit-breakers.*

IEC 61208: *High-voltage alternating-current circuit-breakers — Guide for maintenance*

IEC 61233: *High-voltage alternating-current circuit-breakers. Inductive load switching.*

BS 88-1: *Cartridge fuses for voltages up to and including 1 000 V AC and 1 500 V DC Part 1:*

*Specification of general requirements*

BS 142: *Appendix G, Electrical protection relays*

BS 1872:198: *Specification for electroplated coatings of tin*

SANS 763: *Hot-dip (galvanised) coatings of zinc (other than on continuously coated sheet and wire)*

SANS 1091: *National colour standards*

## **3 DEFINITIONS AND ABBREVIATIONS**

### **3.1 Definitions**

**3.1.1 Special tools:** Any purpose-built tools that are necessary to carry out maintenance on a circuit-breaker and its components. Typical examples of such tools are slow-closing/opening devices, contact-alignment devices, transducers and mounting hardware for such equipment on the circuit-breaker.

### **3.2 Abbreviations**

**3.2.1 ARC:** Auto re-closer

**3.2.2 OEM:** Original equipment manufacturer

**3.2.3 RIV:** Radio influence voltage

## **4 REQUIREMENTS**

### **4.1 Circuit-breaker description**

#### **4.1.1 Functional description**

The circuit-breakers shall be used on City Power's 50-Hz, high-voltage system for general purpose power switching and protection applications, as well as for special purpose applications such as the restrike-free switching of ( $U_m$ ) grounded shunt capacitor banks, shunt reactors and capacitor-reactor combinations duty. For general as well as special purpose applications, the circuit-breakers shall be capable of interrupting all currents from zero to the full symmetrical and asymmetrical rated fault currents at maximum system voltage ( $U_m$ ). The circuit-breakers shall also be capable of performing all duties detailed in schedule A.

#### **4.1.2 Operating conditions**

The circuit-breaker(s) shall operate satisfactorily at City Power's substations under normal current, voltage and short-circuit conditions within the rating of the circuit-breaker(s). The circuit-breaker(s) may be subject to subsequent relocation to any part of the City Power, 50-Hz, high-voltage system and shall be suitable for operation, without modifications, under any condition that may be encountered.

All components, irrespective of their environment and location in the equipment, shall be designed to operate as specified in a temperature range of  $-10^{\circ}\text{C}$  to  $+40^{\circ}\text{C}$ . Sudden temperature changes shall be taken into account. Circuit-breakers shall be able to withstand mechanical stresses due to wind forces as specified in schedule A.

Solar radiation up to a level of  $1\ 100\ \text{W/m}^2$  (on a clear day at noon) shall be considered. The equipment will not be located at elevations higher than  $1\ 800\ \text{m}$ . Dust, smoke, corrosive gas, vapour or salt may pollute the ambient air and the pollution will not exceed pollution level IV – very heavy. The presence of condensation or precipitation shall be taken into account. Vibrations due to causes of earth tremors to the switchgear and control-gear are negligible. The circuit-breaker shall be installed in a manner that ensures safety to personnel. Live parts shall be isolated by means of elevation; the use of protective fences is not acceptable. Moving parts shall be suitably covered and explosion vents shall be orientated so as not to pose any hazard to personnel or adjacent equipment.

#### **4.1.3 Responsibilities for the supply and installation of equipment**

The responsibilities of both City Power and the equipment supplier of the circuit-breakers and associated equipment shall be as defined in this document.

##### **4.1.3.1 Supplier's responsibilities**

The supplier shall be responsible for the supplying the following:

- a) The complete circuit-breaker assembly;
- b) All necessary auxiliary equipment, including operating mechanisms, control, monitoring and protective devices, installed in suitable mechanism cabinets;
- c) All control wiring and terminations inside the circuit-breaker;
- d) All electrical and mechanical interconnections between the elements of the circuit-breaker to City Power's satisfaction;
- e) City Power shall only accept delivery to the destination specified and the supplier shall make all necessary arrangements for acceptance, offloading and trans-shipping at the most convenient point, as well as for offloading at the ultimate destination. Shafts, bearings and machined surfaces exposed during transport shall be treated with a temporary anti-corrosive coating;

- 
- f) The supplier shall supply all necessary bolts and fasters (including fixing bolts) to City Power with the circuit-breakers;
  - g) SF<sub>6</sub> circuit-breaker shall be supplied with the first filling of SF<sub>6</sub> gas to the OEM's required value; and
  - h) Any other responsibilities as set out in this specification.
  - i) Supply and installation of all control, metering, relaying and annunciation equipment remote from the circuit-breaker
  - j) Provision of steel structures for the circuit-breakers throughout. The standard, three-pole, mechanism-breaker single beam must be made adaptable to fit a one-pole breaker as well. The mentioned single beam must be fitted with cover plates over all cut-outs, if applicable. No circuit breakers are to be supplied with integral structures. Details of the circuit-breaker dimensions are stated in schedule A Support steelwork and inter-phase cable racking supplied by the supplier shall be included as part of the circuit-breaker erection activity.

#### **4.1.3.2 City Power's responsibilities**

If stated in the tender document, City Power shall be responsible for the following:

- a) Provision of foundation(s) for the circuit-breaker support structure

## **4.2 Characteristics and performance**

### **4.2.1 Duty cycle**

Where auto-reclosing is specified (as normally required), the circuit-breaker shall be capable of tripping and reclosing the specified number of times. The phases shall operate independently or together, according to the type of auto-reclosing scheme.

Triple-pole and single-pole auto-reclosing (ARC) schemes are employed which require the following duty cycles:

#### *Triple-pole ARC*

O - t - CO (all poles) where t = 300 ms.

A total of one C (close) operation and two O (open) operations shall be stored without requiring the energy source within the mechanism to be recharged.

#### *Single-pole ARC*

O - (one pole) - t - C (one pole) O (all poles) - t' - C (all poles) O (all poles)

where t = 300 ms.

t' = required mechanism recharging time for a OC operation

Where independent pole mechanisms are provided, the circuit-breakers and their control circuits shall be suitable for single-pole auto-reclosing duty even though this may not be specified in schedule A.

**Note:** The supplier shall state the minimum resting time after a duty cycle is carried out *under the most unfavourable conditions* to ensure dependable interruption capability of the circuit-breaker within its rated characteristics.

---

#### **4.2.2 Short-circuit rating**

The supplier shall supply proof of the short-circuit rating in the form of type-test certificates at the tendering stage.

Under certain system-neutral earthing situations, the single-phase-to-earth fault level may exceed the phase-to-phase fault level and a higher single-phase-to-earth fault rating may be required. The factor (if any) by which the 100% symmetrical and asymmetrical single-phase breaking ratings of the circuit breaker exceeds the same three-phase ratings shall be stated at the tendering stage.

#### **4.2.3 Switching surge control, where applicable**

In order to reduce complexity, circuit-breakers that require auxiliary devices in the main circuit (i.e. switching resistors or inductors for switching surge control) will be considered as an alternative only. Depending on the application, the preferred solutions to switching surge control are by means of precise and repeatable operating characteristics (in conjunction with an electronic controller) and/or metal oxide arresters connected in parallel with the interrupting chamber(s).

#### **4.2.4 Delayed, current-zero, interrupting capability**

If specified in schedule A, the capability of the circuit-breaker to interrupt short-circuit currents with a higher degree of asymmetry than required by standards shall be clarified at the time of tendering. Such capability shall be demonstrated by analysis and by high-power test results, which show that the influence of the arc voltage will produce a current zero within the normal arcing time of the circuit breaker.

#### **4.2.5 Shunt capacitor-bank switching**

If specified in schedule A, shunt capacitor banks shall be switched restrike-free. These installations shall be either connected to a station busbar or be part of some other device such as a **thyristor switched VAr. controller**. The maximum ratings of existing shunt capacitor banks are typically 80 MVar. at 132 kV. The backup circuit-breakers in the particular substations may not have adequate capacitive switching capabilities. This means that the circuit-breakers will have to be relied upon to switch the shunt capacitor banks so that the required switching duties can be performed satisfactorily and reliably. The shunt capacitor-bank circuit-breaker may be called upon to switch twice a day, in a single and/or back-to-back situation of the rating specified, with up to three banks installed on a single station busbar. The bank will be disconnected automatically upon operation of the unbalance, over voltage or over current protection systems. The supplier shall specify the maximum value and frequency of inrush and out rush current ratings for the circuit-breakers. Normally, current-limiting reactors will be installed between the circuit-breaker and the shunt capacitor bank being switched in order to obtain transient currents of manageable proportions for the power capacitor elements as well as the circuit-breaker.

The supplier is encouraged to offer special control packages as alternative solutions to assist in the optimum solution of capacitor-bank switching. While the supplier will respond to the specific capacitor ratings stated, City Power shall be informed about the limitations of the switching capabilities for the particular circuit-breaker design. For the sake of standardisation, the circuit-breaker proposed for capacitor-switching duty should preferably be identical to that of a general-purpose circuit-breaker. However, special-purpose circuit-breakers will be considered. All circuit-breakers supplied for the specified capacitor-bank switching duty shall be capable of capacitor switching duty and shall not require controlled opening and/or closing.

#### **4.2.6 Shunt-reactor switching, if applicable**

The circuit-breakers shall be capable of re-ignition-free switching of shunt reactors. The maximum ratings of existing (earthed) shunt reactors are typically 40 MVar. to 50 MVar. at 132 kV. Suppliers may offer special control packages to assist in the optimum solution of shunt-reactor switching.

---

#### **4.2.7 Controlled switching requirements**

For switching of shunt capacitor banks and shunt reactors, the circuit-breakers supplied may be required to perform controlled (point-on-wave) switching duties. The supplier shall provide City Power with all relevant details regarding the mechanical characteristics of the circuit-breaker which affect the mechanical operating time, e.g. influence of ambient temperature, substation DC control voltage, standing time, operating pressure and contact wear. The cause of deviations in operating times shall be indicated in all cases.

The supplier shall provide details of the circuit-breaker, dielectric characteristic as a function of time (closing) and as a function of SF<sub>6</sub>, gas-filling pressure up to the maximum rated design pressure. The supplier shall also supply the upper and lower limits of the dielectric characteristic, which can be expected over the service life of the circuit-breaker. The critical arcing time window shall be indicated for re-ignition-free shunt-reactor switching. For controlled closing of shunt capacitor banks as well as for controlled opening of shunt reactors, a tolerance of less than ± 1 ms is required as a function of the above mentioned parameters. If special measures are required to maintain operating times within these limits is necessary, this shall be stated at the tendering stage. Full details, i.e. the OEM's specification, shall be supplied for the controller (i.e. the controlled switching relay needed to deliver the necessary timed operating command). This information shall also be supplied at the tendering stage.

#### **4.2.8 SF<sub>6</sub> gas requirements**

The SF<sub>6</sub> gas to be used as an insulating and arc-extinguishing medium shall conform to the requirements of IEC 60376. The maximum SF<sub>6</sub> gas leakage rate for the complete equipment shall be stated at the tendering stage. This shall be stated for all the gas in the equipment as well as for any individual gas compartment. Only DIL0 DN8 gas-filling connections shall be accepted.

#### **4.2.9 Synchronism of main contacts**

All interrupters in a pole and in all three poles of the circuit-breaker shall operate simultaneously on opening and closing, including infrequent operation and under extreme temperature conditions. Contact synchronism shall be retained within rated values during the expected maintenance intervals of the circuit-breakers. As an indication of the expected degree of synchronism, the following parameters are laid down:

- a) Timing difference between contact separation for all poles of the circuit-breaker shall not exceed 3 ms.
- b) Time spread between contact separation for interrupters in the same pole shall not exceed 1 ms.
- c) Time interval between contact touch for all poles of the circuit-breaker shall not exceed 3 ms.
- d) Time spread between contact touch for interrupters in the same pole shall not exceed 1 ms.

Consult MMSC on condition monitoring of circuit-breakers.

#### **4.2.10 Rated interrupting times**

These times shall be determined by conditions of *lowest control voltage* and, if applicable, the operating pressure of the mechanism. The maximum break time (i.e. summation of contact separation, arc quenching and mechanical resting time) shall not exceed the value specified in schedule A.

---

### **4.3 Design and construction**

#### **4.3.1 Convention**

As a matter of convention, limit switches, pressure switches, relay contacts are in the normal condition when:

- a) circuit-breaker main contacts are open;
- b) springs are discharged;
- c) mechanism pressure is zero;
- d) gas compartments are without pressure;
- e) relay coils are de-energised; and
- f) no AC or DC supplies are connected.

The schematic-wiring diagram submitted to City Power for approval shall comply with this convention.

#### **4.3.2 Operation interlocks**

##### **4.3.2.1 Sulphur hexafluoride circuit-breakers**

SF<sub>6</sub> gas-filled circuit-breakers shall be provided with densimeters, which shall operate as follows:

- a) On reaching the non-urgent alarm or warning level – i.e. only gas replenishment is necessary; and
- b) On reaching the lockout level – i.e. circuit-breaker to be taken out of service.

The contacts of these switches, on reaching these levels, shall operate relays, which in turn shall perform the following functions:

- a) *Non-urgent or warning alarm level:* One set of electrically separate, normally open and normally closed contacts shall be used for indicating this condition, while the normally closed contacts shall be used for other functions at City Power's discretion; and
- b) *Lockout alarm level:* One set of electrically separate, normally open and normally closed contacts shall be provided. The normally closed contacts shall be wired into all tripping and closing circuits to block operation, while a single, normally open contact shall be wired to terminals to indicate this condition. The use of pressure switches without temperature compensation for the initiation of these functions will not be permitted.

**Note:** It shall be possible to verify the correct operation of gas density/pressure switches *in situ* without having to disconnect wiring or having to perform gas-handling operations on the circuit-breaker.

**4.3.2.2 Circuit-breakers with hydraulic-operating mechanisms**

No hydraulic-operating mechanisms or hydraulic-spring charging is allowed.

**4.3.2.3 Circuit-breakers with spring-operated mechanisms**

A direct means to achieve the following functions shall be provided:

- a) Closing operations shall be possible only when the closing springs are fully charged;
- b) Closing springs can only be released when the main contacts are fully open; and
- c) A device shall be employed to block overcharging of the closing springs when the manual facility is employed.

One spare, normally open and one spare, normally closed spring rewind limit switch of each mechanism shall be used to block an electrical release operation and to indicate this condition.

**4.3.3 Indicating devices**

A mechanical indicating device shall be provided in each mechanism to indicate whether the circuit breaker is open or closed, and shall be clearly visible from outside the mechanism enclosure.

The following symbols shall be used:

Circuit-breaker *closed* "I" in white lettering on a red background;

Circuit-breaker *open* "O" in white lettering on a green background; and

Lettering size shall be at least 30 mm, unless otherwise approved by City Power.

The closing spring condition (charged or discharged) shall be indicated by a mechanical device, which is clearly visible from outside the mechanism enclosure. The words "spring charged" and "spring discharged" shall be displayed in black lettering on a white background. The lettering height shall be at least 15 mm. The use of symbols for the purpose to indicate spring condition shall be subject to approval by City Power.

Pressure gauges (compensated for temperature to reflect SF<sub>6</sub> gas density) shall be provided and shall be sheltered from the elements to provide a correct indication and prevent degradation of the device.

All indicating devices (e.g. SF<sub>6</sub> gas density) shall be clearly readable by a person with normal vision standing at ground level.

**4.3.4 Rating plates/labels**

A nameplate shall be provided for every circuit-breaker and each associated device. For example, the operating mechanism shall be permanently fixed in position where a person with normal vision standing at ground level could easily read it. The nameplates shall contain the necessary information:

- a) Order number;
- b) Name and logo of the manufacturer;
- c) Manufacturer's type designation;
- d) Serial number and the rated characteristics; and
- e) Year of manufacture.

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**13**

OF

**67**

-----

The nameplates and their fixings shall be weatherproof and corrosion-proof. If the switchgear and control-gear consist of several independent poles, each pole shall be provided with a nameplate. All the letters and figures on the nameplates shall be permanently marked. The nameplates shall be securely fastened to the equipment in a reliable manner, and the method of fastening shall be stated at the time of tendering.

The technical quantities and their symbols (which shall be displayed on the rating plate) shall be in accordance with IEC recommendations, and shall include the following:

- a) Rated voltage;
- b) Rated lightning impulse withstand voltage;
- c) Rated switching impulse withstand voltage;
- d) Rated power-frequency withstand voltage;
- e) Rated normal current;
- f) Rated short-time withstand current and duration;
- g) Rated peak withstand current;
- h) Rated short-circuit making current;
- i) Rated frequency;
- j) Rated supply (auxiliary) voltage;
- k) Rated gas pressure for operation, warning level and lockout level;
- l) Rated density of gas for insulation;
- m) Rated gas-filling mass in kilograms;
- n) Contract number;
- o) Standard to which tested (IEC, BSI, SANS, etc.);
- p) Rated operating cycle duty;
- q) First pole-to-clear factor;
- r) Maximum rated capacitive breaking current; and
- s) Maximum rated out of phase 50 Hz voltage across contacts.

Actual ratings to which the circuit-breaker has been type-tested (and not merely the values specified in schedule A) shall be displayed. Labels associated with local operation of the circuit-breaker shall be in English and shall be as follows:

*Instructions for opening and closing the circuit-breaker:* These instructions are "TO TRIP" and "TO CLOSE" respectively. Additional information required to perform these functions shall be referred to City Power.

*Instructions for recharging closing springs:* The instruction is "SPRING CHARGE".

*Rating label inside operating mechanism:* This label shall state at least the following:

- a) Type designation;
- b) Trip-coil voltage, current, DC resistance (at 20 °C);
- c) Close-coil voltage, current, DC resistance (at 20 °C); and
- d) Motor voltage and current (starting peak current and nominal running current).

These shall be the nominal values (with tolerances) according to the routine test parameters. Rating labels shall be either engraved aluminium or stainless steel and are subject to approval by City Power.

#### **4.3.5 Auxiliary switches**

Auxiliary switches shall faithfully reproduce the main contact position. In addition to the auxiliary contacts required for control interlocking, the number and type of auxiliary contacts required for each mechanism shall cover the requirement specified in schedule A. These contacts shall be independent (i.e. not changeover contacts) and fixed. Auxiliary contacts shall reproduce main contact timing to acceptable limits approved by City Power. If possible auxiliary contact timing shall permit adjustment within limits to be given by the supplier at the time of tendering.

All spare, auxiliary switch contacts shall be wired independently to the secondary terminals. The use of auxiliary relays to multiply the number of auxiliary contacts required is not acceptable. Auxiliary switch contacts shall be protected against ingress of dust particles. Where City Power considers it necessary, dust guards shall be fitted at no extra cost. Cascading of auxiliary switches via mechanical means is acceptable provided that mechanical endurance testing has been satisfactorily carried out. Proof of this shall be submitted at the tendering stage.

#### **4.3.6 Mechanism motors**

Mechanism motors shall be suitable for the control voltage of 110 V DC as specified in schedule A.

Contactors with thermal overload and single-phasing protection facilities shall control alternating current motors. These devices shall comply with IEC 60158-1 and IEC 60947-4-1.

Motors shall be designed, rated and tested to IEC recommendations and for the operating voltage specified. The use of resistors to achieve voltage reduction from the control voltage is not acceptable.

#### **4.3.7 Types of mechanisms**

##### **4.3.7.1 General**

The mechanisms shall be designed in such a way that in the case of failure to latch or of a command to trip during a closing operation, safe conditions are produced for the elements interrupting the circuit breaker.

##### **4.3.7.2 Motor-wound spring**

Automatic rewinding of closing springs shall be provided by means of an interlock arranged via a normally closed spring-rewind limit switch contact. At City Power's discretion, a normally open auxiliary switch contact shall be included to permit this operation only when the circuit-breaker is closed. To allow local rewinding of springs when the circuit-breaker is open, a readily accessible push-button (painted black) or spring return to "off" position switch (in parallel with the normally open auxiliary switch contact) shall be provided in each mechanism. Provision shall also be made in each mechanism for the remote rewinding of springs when the circuit-breaker is open.

-----

In all cases, motor control contactors shall be provided and contactor coils shall have their current interrupted by the spring-rewind limit switches. Motor contactors shall be rated to break the maximum motor current. A second set of normally closed spring drive limit switch contacts shall be provided in the motor circuit itself.

All contacts in motor rewind circuits shall be capable of interrupting the maximum current drawn by the device being operated in their respective branch of the circuit.

Motor rewind circuits shall be approved by City Power.

In addition to the spring-rewind limit switch contacts required for motor control, spare contacts of the type and quantity specified in schedule A shall be provided. One of the normally open limit switch contacts may be used for sequential starting of spring-recharging motors in the other poles or circuit breakers. The rating of this contact shall be adequate for such duty. If the rating of this contact is not adequate, a control contactor that is under command of this contact shall be provided to achieve this capability.

Circuit-breakers equipped with independent phase-operating mechanisms and motor control contactors shall be provided with a 10 A, 800 V peak inverse voltage diode for each mechanism. This diode shall be mounted and wired to terminals. A means of manually tripping and closing the circuit breaker shall be provided, and the method used shall be explained clearly in the tender documents.

Appropriate warning labels shall be displayed to draw attention to the danger of performing manual operations without an adequate amount of SF<sub>6</sub> gas inside the gas compartments of the circuit-breaker.

#### **4.3.8 Degrees of protection by enclosures**

Circuit-breaker mechanisms, local control facilities and all parts requiring lubrication shall be protected by weatherproof enclosures. The degree of protection afforded by these enclosures shall, as a minimum requirement, comply with IEC 60529 according to the following classifications. Enclosures containing exposed bearings, auxiliary switches, motors and other electrical devices shall comply with IP 55. All other enclosures provided shall comply with IP 53. Upper surfaces of enclosures shall be shaped or sloped to prevent accumulation of water. Mechanism enclosures shall have hinged doors allowing clear access to control levers, push-buttons, fuses and secondary terminal strips. These shall be easily accessible from ground level. Doors shall be equipped with travel stops, which shall retain the door in the open position. Devices requiring adjustment/periodic maintenance shall be readily accessible and any removable covers provided shall have bolt fastenings subject to City Power's approval. All bolts shall have hexagon heads. Self tapping screws, captive head nuts or cage nuts are not acceptable. A gauze-covered drain hole with a minimum diameter of 25 mm and having no internal rim or ledge that is likely to obstruct drainage shall be provided at the lowest point of the enclosure. Gaskets shall be made of neoprene or heavy duty foam-plastic. Felt or natural rubber gaskets are not acceptable.

Suitably rated electric heaters shall prevent moisture from condensing and being deposited inside the mechanism enclosures. Heaters shall maintain a dew point greater than the ambient temperature and shall circulate the air constantly to all parts of the enclosure. Heaters shall be placed to avoid damage to temperature-sensitive components. Heater elements shall be shrouded and leads, which are heated by the conduction of heat from the element, shall be insulated by heat-resistant insulating material, e.g. ceramic beads or silicone rubber. The electrical supply for heaters will normally be single-phase 230 V AC. The circuit shall have a normally open auxiliary contact to indicate failure of the AC supply to the heater.

-----

The contact shall be on the heater side of the fuse. Where single heaters are provided, these shall be permanently connected. Heater circuits shall not be equipped with local isolating switches, but with a local fuse-link and a solid link. The total power drawn by heaters shall not exceed 400 W, unless otherwise approved. Enclosures shall permit entry of cables from below, which also applies to pipe work run in ground trenches.

**Note:** Plastic or fiber-reinforced plastic materials for mechanism enclosures, or other applications where exposure to the elements is involved will be not accepted.

#### **4.3.9 Main terminals**

##### **4.3.9.1 MV terminals**

The circuit-breaker main terminals shall be constructed of an aluminium flat pad with 8 x 50 pitch.

##### **4.3.9.2 Earthing terminals**

- a) The main earth terminal shall comprise a stainless steel (grades 304 and 316) plate, welded to the beam.
- b) The plate shall be a minimum of 40 mm deep and shall be fitted with a stainless steel bolt, washer and spring washer.
- c) The bolt shall be a fully threaded M16 x 35 mm bolt, threaded through.
- d) The main earth terminal shall be located directly above one of the support legs.
- e) A suitably rated connector (not copper) shall be provided between the plate and the support leg. (The beam and support structure shall provide continuity between the breaker and the holding-down bolts).

##### **4.3.10 Fittings**

SF<sub>6</sub> gas-filled circuit-breakers shall be provided with the following fittings:

- a) A gas density or pressure manometer shall be installed (a gas density manometer is the preferred arrangement). SF<sub>6</sub> gas pressure shall be numerically expressed in kPa;
- b) A common gas-filling/evacuating and gas density-monitoring point for the whole circuit-breaker is preferred for voltages up to 132 kV;
- c) Pressure gauges shall be marked and calibrated in Pa (SI units). Only gauge pressure shall be indicated and rated pressure shall be no more than 80% of the full scale reading;
- d) The gas density/pressure-monitoring device shall be suitable for outdoor application and resistant to operating vibrations, UV rays, outdoor weather (e.g. rain/hail/snow) and being stepped on accidentally. It shall also give a positive and reliable response on reaching the operating values (no contact bounce);
- e) Device actuation and de-actuation differentials shall be consistent over the ambient temperature range as specified in schedule A;
- f) Electrical connections to the density-monitoring devices shall preferably not be the plug-in type. However, density-monitoring devices with locking facilities will be accepted;
- g) The gas density monitor cable connection shall be secured and protected from the elements in an approved manner;
- h) Any pipe-work shall be made of copper and mounted in such a manner that it is mechanically protected;

- 
- i) The gas density monitor functionality shall be retained (i.e. non-return valves shall be fitted) when the circuit-breaker is removed without the circuit-breaker being de-energised. The supplier shall submit details on the arrangements suggested together with the tender documents; and
  - j) Complete details of all gas-monitoring devices, including drawings, manufacturer's specifications, performance and test data, details of production tests and a quality control programme, shall be included at the tendering stage.

#### **4.3.11 Corrosion protection**

The mechanism box shall be manufactured from corrosion free marine-grade (316) stainless steel. The breaker beam may be manufactured from galvanised mild steel. For all SF<sub>6</sub> gas-filled circuit-breakers, the insulator flange cementing shall be protected inside and out with an application of suitable polymeric material (i.e. RTV silicone sealant of appropriate quality). All corrosion protection measures applied to the circuit-breakers shall be detailed and submitted at the tendering stage.

#### **4.3.12 Insulation**

##### **4.3.12.1 Insulators and bushings**

Insulators or bushings shall be interchangeable with similar insulating components and shall comply with the relevant IEC 60273 requirements.

##### **4.3.12.2 Creepage distance**

The total creepage distance to earth (which, where applicable, is in parallel with the main circuit contacts) shall be as specified in schedule A.

##### **4.3.12.3 Clearance in air**

The phase-to-earth and phase-to-phase clearances, measured by the taut string method, shall be stated in schedule B. City Power reserves the right to call for clearances greater than those already successfully proven by dielectric tests.

#### **4.3.13 Closing devices**

Electrically operated closing devices, including mechanism-charging motors, shall be suitable for operating at any DC voltage between 70% and 110% of the nominal control voltages measured at the device terminals. The circuit-breaker shall close correctly when an electrical closing pulse of 100 ms duration is applied to the closing coil. When closing all phases simultaneously, the total power drawn by the operating coils of the circuit-breaker shall not exceed 1500 W (i.e. 500 W/pole). Each closing coil shall be provided with a normally closed auxiliary contact in series, to allow closing only when the circuit-breaker is open. For spring-operated mechanisms, an additional normally open spring-drive limit switch in this circuit shall also be included to prevent damage to the closing coil if a sustained closing pulse is applied when the closing springs are not fully charged.

Closing devices shall not operate if a 10 µF capacitor, charged to 1,5 times the nominal DC control voltage, is discharged through the operating coil.

Closing coils shall be clearly marked with the operating voltage and actual resistance value at 20 °C.

#### **4.3.14 Tripping devices**

Electrically operated shunt-opening devices shall be suitable for operation at any DC voltage between 70% and 110% of the nominal voltages, measured at the device terminals. When the circuit-breaker is not carrying current, satisfactory operation shall be possible at, *but not lower than*, 70% of the nominal supply voltage measured at the device terminals. The total power drain by the circuit-breaker opening

-----

coils (trip coils) of any one system when opening all phases simultaneously shall not exceed 1 500 W (i.e. 500 W/pole).

Normally open auxiliary contacts in series with the trip coils shall be provided to interrupt the operating current and prevent damage to trip coils if a tripping impulse is sustained. Duplicate, normally open contacts in parallel for each trip coil shall be provided. Each circuit-breaker shall be equipped with at least one electrical shunt-opening system for each mechanism. If specified in schedule A, each circuit-breaker shall have an additional identical electrical shunt-opening system as a backup. However, each shall be electrically separate in order to facilitate fuse circuitry associated with the independent control systems applied to either system. Neither trip coil shall influence the operation of the other if one is damaged. Trip coils shall not have a particular polarity, nor shall they affect operation when energised simultaneously.

Opening devices shall not operate if a 10  $\mu$ F capacitor, charged to 1,5 times the nominal DC control voltage, is discharged through the operating coil.

Trip coils shall be clearly marked with the operating voltage and actual resistance value at 20 °C.

#### **4.3.15 Anti-pumping**

All circuit-breakers shall be equipped with anti-pumping circuitry. Anti-pumping arrangements shall be subject to City Power's written approval and shall be demonstrated as part of the routine and site-testing procedures.

#### **4.3.16 Control relays**

All control relays shall be standard products that are freely available on the commercial market and shall be labeled in accordance with the schematic wiring diagram for the circuit-breaker.

Control relays shall not operate if a 10  $\mu$ F capacitor, charged to 1,5 times the nominal DC control voltage, is discharged through the operating coil.

#### **4.3.17 Pole discordance or phase discrepancy (PD)**

The following applies only to circuit-breakers with independent pole mechanisms:

A pole discordance (PD) or phase discrepancy condition is when one or more poles do not perform an operation in harmony with the other poles. If this persists for at least 100 ms, then the control circuitry associated with the circuit-breaker shall immediately initiate a trip command to all poles.

The PD timer and its associated circuitry shall be provided under a separate contract and is located in the remote control panel associated with the particular circuit-breaker. This timer will receive its signal from a combination of normally open and normally closed spare, auxiliary switch contacts. In order to determine the correct setting for this timer, it is necessary for the supplier to provide information at the tendering stage about the following timing events (with tolerances) between:

- a) main contact timing and the auxiliary contacts timing of the same pole for both opening and closing operations; and
- b) main contact timing and the auxiliary contacts timing between all poles for both opening and closing operations assuming the open and close command is received simultaneously by all poles.

In the case of single-pole auto-reclosing, where an intentional PD will exist for times in excess of 1 000 ms, the control circuitry shall deliberately permit this condition.

#### **4.3.18 Secondary terminals**

Secondary terminals to which City Power's cables will be terminated shall be of an approved type (spring loaded terminals) and shall be suitable for use with crimped or compression-type terminations.

---

#### **4.3.19 Terminal strips and gland plates**

Auxiliary switches, internal wiring and other equipment requiring connection to external apparatus shall be wired to terminal strips in the circuit-breaker mechanism box. Each terminal strip shall be provided with not less than 10% spare terminals, and shall have a minimum of two. The arrangement of the terminal strips (vertical orientation) in the equipment shall facilitate the entry of the incoming control cables in the bottom-entry configuration. Where control cabling is provided by City Power, the cabling shall be multi-core, PVC-insulated, single-wire, armoured and PVC-sheathed. It shall be complete with compression-type glands, for which a removable, undrilled, brass or aluminium gland plate of the specified minimum size (i.e. 5 mm) shall be provided at the base of the enclosure and below the terminal strip. To facilitate control, cable entry and connection, the distance between any part of the terminal strip and the gland plate shall not be less than 150 mm.

Any deviations from the provisions of this section shall be subject to approval by City Power.

#### **4.3.20 Wiring, terminations and identification**

Wiring for motor circuits shall be carried out in multi-stranded conductor with a minimum area equivalent to 2,5 mm<sup>2</sup> and insulated to withstand a test voltage of 2 kV to earth for 1 min. Wiring for control circuits shall be carried out in wire of at least 1,5 mm<sup>2</sup> and shall be insulated to withstand a test voltage of 500 V to earth for 1 min. Secondary wiring shall be identified at both ends in an approved manner (e.g. by ferruling), and shall present a neat appearance. It shall be braced, placed in plastic troughing, clipped and/or laced to prevent vibration. All secondary and equipment terminals, labels and shall be completely accessible after the wiring and cabling have been completed. Wiring to equipment located on swing doors or frames shall be arranged vertically over the hinge so that the wiring is twisted and not bent. For all wires without lug terminations, the numbered ferrule may not fall off when disconnecting the wire. In this regard, the use of one or more strands of wire to retain the ferrule is not acceptable. Where relays, fuses, lamps are provided with the screw-down type of terminal (where the screw comes into direct contact with the conductor), crimping wire-pin terminations shall be used. Secondary cabling provided by the supplier shall be UV-resistant and preferably be run in the ground, in which case steel wire armoured cable shall be used.

Any deviations from the provisions of this section shall be subject to approval by City Power.

#### **4.3.21 Electromagnetic compatibility**

Induced electromagnetic disturbances in the secondary system of the circuit-breaker shall not cause spurious operation or damage. This applies both under normal operation and under switching conditions, including interruption of fault currents in the primary system. The secondary system consists of the following components:

- a) Control and auxiliary circuits, including circuits in central control cubicles, mounted at or adjacent to the circuit-breaker;
- b) Equipment for monitoring, diagnostics that form part of the circuit-breaker; and
- c) Any circuits that are connected to the secondary terminals of instrument transformers and that form part of the circuit-breaker installation.

The secondary system shall be restricted to the circuits, which relate directly to the circuit-breaker concerned.

#### **4.3.22 Requirements for sulphur hexafluoride (SF<sub>6</sub>) gas**

When erection is called for, SF<sub>6</sub> circuit-breakers shall be filled with new SF<sub>6</sub> gas at the rated normal pressure. New SF<sub>6</sub> gas shall comply with the requirements of IEC 60376. Gas storage vessels shall be manufactured and tested in accordance with a code of practice recognised by the Occupational Health and Safety Act (see annex C). Measures shall be taken to prevent ingress of contaminants such as moisture and dirt as well as over-pressurising during the gas-filling process.

**4.3.23 Control voltage**

The operating coils (closing and tripping) to be supplied with the circuit-breakers shall be suitable for operation at 110 V DC. The supplier will be informed a reasonable time before equipment is delivered about the number of circuit-breakers to be supplied for each different control voltage. Each circuit breaker shall only be required to operate at one control voltage. However, it shall be possible to change the control voltage at which the circuit-breaker operates by merely replacing the operating coils and motor contactors. Unless specifically stated in the tender, it will be assumed that the unit prices of the circuit-breakers will remain the same, regardless of the control voltage. The motor contactor coil shall be suitable for operation at 110 V DC.

**4.3.24 Motor voltage**

Mechanism motors shall be suitable for 110 V DC operation.

**4.3.25 Rating of equipment**

The supplier is required to state the actual ratings to which the equipment has been certified at the tendering stage in schedule B.

**4.3.26 Operation counters**

Mechanical operation counters are preferred. Circuit-breakers with independent operating mechanisms shall be equipped with a counter for each pole. The circuit-breaker operation counter shall be non-resettable.

The counter shall have, at least, a capability of counting up to 9 999 operations. The supplier shall submit full details of the operation counter on request by City Power.

**4.3.27 Information on design changes**

During the period covered by the contract, the supplier shall not make any changes to the equipment supplied without giving City Power prior notice and without first receiving approval from City Power. If the supplier decides to modify/change the agreed-to design of the circuit breaker, then the change(s), together with the reasons for wishing to make the change(s), shall be forwarded to City Power in writing. This shall be sent to the Technology Services Substation Work Group.

**4.3.28 Lubricants such as greases**

The behavior of lubricants that are exposed to air, SF<sub>6</sub> gas and its arcing products shall be stable over the intervals between maintenance. The supplier is required to identify the lubricants used and to submit details of tests carried out to prove suitability for the application. If possible, a list of equivalent lubricants from South African sources shall be provided.

**4.3.29 Flange corrosion**

For SF<sub>6</sub> gas-filled circuit-breakers, the supplier shall give details in his/her tender of the measures taken to prevent flange corrosion. These details shall include drawings of the flange arrangements, treatments and service experience.

---

## **4.4 Maintenance considerations**

### **4.4.1 Accessibility**

It shall be possible to check pressure gauges, circuit-breaker positions from ground level without opening doors or covers.

Mechanism enclosures shall be arranged to facilitate complete access for inspection and permissible *in situ* cleaning, lubrication, repairs and adjustments to the mechanism.

### **4.4.2 Maintainability**

Circuit-breakers shall be designed for minimal maintenance.

The operating mechanism shall be totally accessible from all sides for routine maintenance.

Where applicable, the tools required for regular maintenance shall consist of the following:

- a) Slow-operating device(s);
- b) Hoses and fittings for draining and filling with SF<sub>6</sub> gas; and
- c) Special tools, which may be, required (e.g. contact alignment tools, SF<sub>6</sub> densimeter checking device).

Separate prices shall be quoted for this equipment in the pricing schedules. A detailed list of maintenance equipment shall be supplied at the tendering stage. This equipment will normally be consigned to the same site as the circuit-breakers. Allowance shall be made to supply at least one set of equipment for each site.

If, during the normal life of the supplied circuit-breakers, City Power requires to be notified about a necessary modification a field service bulletin shall be issued giving details of the modification and the reason for it. The supplier is encouraged to develop practical and innovative methods to improve the reliability and maintainability of the circuit-breaker installation. This may include on-line monitoring and/or integrated diagnostic devices achieving the following functions:

- a) Accumulated interruption amperage values (per pole);
- b) Contact wear (per pole);
- c) Continuous measurement of SF<sub>6</sub> gas density. The instrumentation will provide information enabling early warning of SF<sub>6</sub> gas leaks and planned outages for refilling or repairs;
- d) Analyser for SF<sub>6</sub> gas quality and decomposition products; and
- e) Continuous monitoring, recording and alarm signaling of the mechanical operating characteristics of the circuit-breaker.

### **4.4.3 Construction**

The design and layout of the circuit-breaker, including control cable interfacing, shall facilitate rapid installation in the field with a minimum of on-site assembly work. The factory assembly shall be maximised.

The following concepts shall apply to the design of the equipment:

- a) The various elements of the circuit-breaker shall be standardized;
- b) Modular, pre-assembled elements shall be designed to facilitate handling and installation; and

- c) The equipment shall be designed to promote construction and maintenance convenience for personnel;

The following information shall form part of the instruction manual of the circuit-breaker:

- a) The levels of expertise required for the construction crew;
- b) A man-hour estimate for the assembly work required at site;
- c) A list of special equipment and tools required for unloading and positioning components of the breaker on site;
- d) The measures required to make sure all the manufacturer's transportation and storage requirements are met; and
- e) Tolerances for field assembly.

The supplier shall supply a video recording or DVD to supplement construction and installation information given in the instruction manual. This visual information may be provided separately or may be part of the maintenance video recording required.

A copy of such a videotape or DVD shall be available for viewing at the time of tendering.

#### **4.4.4 Rules for transport, storage, erection, operation and maintenance**

The transport, storage and erection of switchgear and control-gear, as well as their operation and maintenance in service, shall be carried out in accordance with the instructions given by the OEM. Consequently, the supplier shall provide instructions for the transport, storage, erection operation and maintenance of the equipment according to the requirements set out by the OEM. Instructions for the transport and storage shall be given at a convenient time before delivery, and the instructions for the erection, operation and maintenance shall be given by the time of delivery at the latest.

##### **4.4.4.1 Transport, storage and erection**

###### **Transport**

Conditions can be expected to be onerous during transport, storage and erection. Adequate precautionary measures are essential for the protection of sensitive components such as insulating parts and mechanisms during transport, storage and erection. Vibrations and impacts during transport shall also be considered. The equipment shall be designed, manufactured and packed appropriately to contend with the conditions arising during shipping and handling. The supplier shall demonstrate – either by testing or through previous satisfactory experience – that the equipment complies in this respect. Testing may include the following:

**Shipping test:** The test shall cover all the conditions to be encountered during transportation from factory to the designated site, including loading/unloading from one mode of transport to the other.

**Vibration test:** The test may be used to supplement actual shipping tests to check for unexpected shortcomings in the equipment and packaging.

**Weatherproof test:** This test may demonstrate the adequacy of the packing to prevent ingress of water from weather or sea conditions.

If the design of the equipment is mature, and the equipment has previously been shipped under similar conditions, shipping tests may be waived at City Power's discretion. City Power will only accept delivery at the destination specified and the supplier shall make all necessary arrangements for acceptance, offloading and trans-shipping at the most convenient point, as well as for offloading at the ultimate destination.

---

### **Storage and erection**

The equipment shall be protectively packed to prevent damage during storage at site. Exposed shafts, bearings and machined surfaces shall be treated with a temporary anti-corrosive coating. Equipment may be stored for extended periods on site before erection commences. In such instances, City Power shall be given clear instructions on the storage and care of components, including any interim maintenance instructions.

### **Packaging**

Each circuit-breaker shall be *unit-packed*. In other words, the component parts making up a complete circuit-breaker shall be delivered to the site in one or more packing cases and these packing cases shall contain only the component parts for one individual circuit-breaker. City Power will not accept equipment if the various component parts of the different circuit-breakers are delivered in the same packing case. Packing cases shall be clearly marked to indicate what they contain, and if one circuit breaker is delivered in more than one packing case, the cases shall be marked in such a way that it is easy to identify the circuit-breaker to which they belong. The following minimum information shall appear on the box: make, type and serial number of the circuit-breaker, and also an indication of the number of boxes for one circuit-breaker, e.g. 1 of 4, 2 of 4, etc.

### **Maintenance of equipment in storage**

Equipment shall preferably not require any maintenance whilst it is being stored prior to being erected. If any equipment requires maintenance or attention during storage, this shall be clearly stated in the contract and City Power's attention shall be drawn to this fact at the time of delivery of each item of equipment requiring maintenance or attention. Failure to comply with the above shall render the supplier liable for any damage that may occur owing to maintenance not having been carried out during storage.

## **4.5 Erection**

When a circuit-breaker must be erected, this activity and the associated pre-commissioning testing shall be the responsibilities of the supplier.

Normally City Power will supply support structures under a separate contract. Erection shall include offloading and supply of all installation and test equipment. This equipment shall be removed from site when erection is completed. Erection shall include filling with of gas and the site testing (pre-commissioning tests) of the circuit-breakers as specified. For each type of circuit breaker, the instructions provided by the supplier according to the OEM's instructions shall at least include the items listed below.

**Unpacking and lifting:** All information required for unpacking and lifting safely shall be given, including details of any special lifting and positioning devices that are necessary.

**Assembly:** When the circuit-breaker is not fully assembled for transport, all transport units shall be clearly marked. Drawings showing the assembly of these parts shall be provided with the circuit breaker.

-----

**Mounting:** Instructions for mounting the base frames poles, operating device(s) and auxiliary equipment shall include sufficient details to enable site preparation to be completed.

These instructions shall also indicate:

- a) the total mass of the apparatus, inclusive of extinguishing or insulating fluids;
- b) the mass of extinguishing or insulating fluids; and
- c) the mass of the heaviest part of the apparatus to be lifted separately if it exceeds 100 kg.

**Qualification of staff:** All staff employed by the supplier who are involved in the erection and commissioning of the circuit-breaker shall be trained and accredited by the OEM. Proof of this accreditation shall be included in the Quality Plan and shall be submitted to City Power for approval prior to erection and commissioning of equipment by the individuals concerned. This information shall include the substation site and the circuit names, together with the dates that the work was performed.

Ensuring the training and accreditation of persons employed for the erection and commissioning of circuit-breakers shall be the responsibility of the supplier. During the performance of the work at the substation site, the supplier shall comply with all the relevant statutes, regulations, bylaws and codes, as well as all the safety and quality requirements pertaining to the work. The supplier shall provide all apparatus including safeguards and personal protective equipment necessary for the performance of the work.

**Final installation inspection:** Instructions shall be provided for inspection and a test shall be carried out after the circuit-breaker has been installed and all the interfacing connections have been completed. These instructions shall include the following:

- a) Procedures for carrying out any adjustment that may be necessary to achieve correct operation;
- b) Recommendations for any relevant measurements that shall be made and recorded to help with future maintenance decisions; and
- c) Instructions for final inspections and implementation.

## **4.6 Operation**

The instructions given by the supplier shall contain at least the following information:

- a) A general description of the equipment with particular attention given to the technical description of its characteristics and operation so that the City Power staff concerned have an adequate understanding of the main principles involved;
- b) A description of the safety features of the equipment and the operation of the interlocks and padlocking facilities; and
- c) Where relevant, a description of the action to be taken to manipulate the equipment for operation, isolation, earthing, maintenance and testing.

---

## **4.7 Maintenance information**

The effectiveness of maintenance depends mainly on the way instructions are prepared by the OEM and implemented by City Power. The supplier shall supply maintenance information in the form of maintenance manuals, field service bulletins and video material covering the following aspects.

**Extent and frequency of maintenance:** For this purpose, the following factors shall be considered:

- a) Switching operations (accumulated switching amperage);
- b) Total number of operations;
- c) Environmental conditions; and
- d) Measurement and diagnostic tests (if any).

**Scope of work to be performed:**

- a) Recommended place for the maintenance work (indoor, outdoor, in factory, on-site, etc.);
- b) Procedures for inspection, diagnostic tests, examination overhaul;
- c) Reference to drawings;
- d) Reference to part numbers or standard kit of parts;
- e) Tools required, including special equipment or tools;
- f) Precautions to be observed (e.g. cleanliness and possible effects of harmful arcing by-products);
- g) Lubrication procedures; and
- h) Cleaning materials.

**Graphical information:** Detailed drawings and sketches of the circuit-breaker components, with clear identification (part number and description) of assemblies, sub-assemblies and essential components. Expanded detail drawings, which indicate the relative position of components in assemblies and subassemblies, are expected as a preferred illustration method. Graphs and similar means of portraying important information shall also be included.

**Specified operational values:** Values and tolerances which, when exceeded, make corrective action necessary, for example:

- a) Pressure and density levels;
- b) Switching resistor and grading capacitor;
- c) Operating times and contact velocities;
- d) Motion damping action;
- e) Resistance of the main current carrying circuits;
- f) Insulating liquid or gas characteristics;
- g) Quantities and quality of liquid or gas;

- h) Torque settings for fasteners; and
- i) Important dimensions.

**Specifications for materials:** This includes warnings of known non-compatibility of materials.

- a) Oil;
- b) Fluid; and
- c) Cleaning and degreasing agents.

**Special tools, lifting and access equipment**

**Tests after the maintenance work:** All tests shall be clearly described and shall include the parameters to be observed.

**Spare parts:** Description, reference number, quantities and advice for storage

**Time estimates:** Of active scheduled maintenance time

**Detailed information:** This relates to the recommended makes and types of transducers (linear or rotary) to facilitate the measurement of travel curves. Such transducers (as well as the brackets, fittings that are needed to apply them on the circuit-breaker) are part of the special maintenance tools for the circuit-breaker. The manual shall show clearly how the transducer, together with any brackets, fittings, etc, shall be mounted and applied on the circuit-breaker.

Mechanism heaters shall be working. If a thermostat is fitted the cut-out shall be set at approximately 25 °C.

## **4.8 Instruction manuals**

City Power will advise the supplier of the number of manuals to be supplied in schedule A. The instruction manual shall cover erection, assembly, operation and maintenance and shall fulfill the following specification:

- a) It shall be specifically compiled for the circuit-breaker with which it has been supplied;
- b) Torque wrench settings, clearances, settings and other important statistics shall be listed, e.g. the typical operating times, speed curves and tolerances in synchronism;
- c) It shall give a clear description of the operation, and the diagrams and description shall be easily read together;
- d) Routine minor and major maintenance procedures shall be given together with a list of lubricants, recommended spares and/or special tools, required for these operations;
- e) It shall contain high-quality diagrams showing details of operating components of the circuit breaker, which also identify and list separately each component making up the diagram;
- f) Seals and gaskets requiring replacement during overhaul shall be detailed and the suppliers of these components, together with the stock number(s), shall be listed;
- g) The names and addresses of supplies of lubricants, gases, compounds shall be listed; and
- h) One set of sample manuals shall be supplied to City Power with the tender for approval. After approval, the requisite number of manuals shall be supplied.

-----

Qualified maintenance personnel will maintain and repair the equipment with the aid of the manufacturer's instruction manuals and video aids. Therefore, a detailed, accurate and structured instruction manual is vital. The supplier shall provide a videotape to supplement written material in the instruction manual; this videotape or DVD shall be submitted at the tendering stage. The instruction manual shall be written in English only. The instruction manual and the maintenance videotape or DVD shall be specific to the equipment supplied. The contents of the instruction manual have, to some extent, already been described in the previous subsections of this document. In summary, it shall contain the following information.

***Part one: General***

- a) Title page: Title of equipment, equipment ratings, contract and order numbers, supplier's reference numbers. This information shall also appear on the outside of the binder and on the first page;
- b) Table of contents: The manual shall be sectionalised and numbered sequentially;
- c) List of drawings and summaries, by number and title, including serial numbers of equipment to which the manuals apply;
- d) Storage instructions: Indoor, outdoor and special information for equipment storage;
- e) Description of circuit-breaker operation;
- f) Full details of method adopted to prevent pumping;
- g) Where applicable, details of interlocking between phases;
- h) Where applicable, details of auto-reclosing arrangements;
- i) Schematic of circuit-breaker; and
- j) Where applicable, full details of all valves, including information regarding materials of valves and valve seats. If materials such as synthetic rubber or other equivalent types are used, the method of bonding or clamping these materials shall be given.

***Part two: Installation instructions***

Complete step-by-step instructions and detailed drawings, including alignment, erection and dimensional tolerances, for preparing the equipment for service. Inspection procedures before and after unloading, pre-erection tests, gas-filling and monitoring procedures shall be included.

***Part three: Testing***

Functional testing, dielectric testing, operating instructions, operating limits and starting-up instructions (complete with sketches or drawings) shall be provided. A separate set of record sheets shall be provided, showing measurements and tolerances for each test for separate items of equipment.

***Part four: Dismantling, repair, settings inspection and lubrication***

- a) Maintenance instructions for dismantling the equipment, as well as repair instructions and settings of critical clearances and adjustments, complete with photographs and sketches or drawings;
- b) Special tools shall be clearly described;
- c) Guide to inspection frequency;

- 
- d) All gaskets, seals and O-rings, which have to be replaced during routine maintenance or after a specified period, shall be identified;
  - e) Lubrication chart and schedule (including component quantities). Lubricants shall be clearly identified. If no lubrication is required, it shall be clearly stated;
  - f) Procedures for the discharge of stored energies in the mechanical, hydraulic and electric systems;
  - g) Procedures for the safe disposal of decomposed SF<sub>6</sub> gas products shall be described; and
  - h) Trouble-shooting procedures shall be provided.

***Part five: Spare and renewal parts***

- a) Spare parts list, including quantities and manufacturer's part numbers. Spare parts numbers shall be cross-referenced with drawings in the instruction manual;
- b) Drawings (sectional or "exploded" views, etc.) of the equipment/sub-assemblies shall identify every component (excluding standard bolts, nuts, washers, etc.) referenced to the spare parts list, including component description and manufacturer's part number; and
- c) Delivery times for recommended spare parts shall be stated.

***Part six: Drawings and data for equipment***

The manufacturer shall provide a complete set of approved drawings specific to the equipment being supplied. The drawings shall show dimensions and tolerances of the major components and assemblies. Details on the drawings needed are given in section 4.13.

## **4.9 Maintenance videotape or DVD**

It is anticipated that maintenance intervals for the circuit-breakers will be very long, e.g. several years. Consequently, it is essential that the instruction manual be supplemented and supported by a maintenance-orientated video recording. The videotape or DVD shall provide a record of the maintenance requirements and procedures for the equipment supplied. The videotape or DVD and related instruction and maintenance manuals shall be detailed enough to enable a trained maintenance crew (with some general knowledge of the equipment) to perform all minor and major maintenance required on the equipment. It is anticipated that the instruction manuals will list what maintenance is required, while the videotape or DVD will show how such maintenance is achieved. The videotape or DVD shall cover the routine minor maintenance and major overhaul of all equipment requiring such work, as well as some troubleshooting techniques and tips. It shall explain the normal operation of the equipment in sufficient detail for the maintenance crew to be able to differentiate between normal and abnormal equipment performance. The videotape or DVD shall concentrate on equipment maintenance and shall not include any unnecessary sales or publicity material. Since the topics to be covered are extensive and complex, it may be considered an advantage to both produce the videotape or DVD and present the results in definite sections, covering the various aspects or portions of the equipment. These sections may be on separate discs or cassettes, or if consolidated into a single cassette or discs, there shall be adequate indexing to permit quick access to the desired section.

For each piece of equipment requiring maintenance, the videotape or DVD shall show:

- a) The tools, equipment and materials required to perform the maintenance, especially any special tools;
- b) The tests required prior to maintenance operations to record the status of the equipment and/or to indicate the areas requiring maintenance/re-adjustment;

- 
- c) The disassembly steps, including any marking of positions required prior to disassembly, any discharging of pressure and/or release of stored energy;
  - d) The disassembly, removal, replacement and re-assembly of any sub-components requiring routine maintenance/replacement;
  - e) The re-assembly, realignment and re-installation of all components, including any lubrication of moving parts;
  - f) A brief summary of the evacuation, refilling and leak testing of the re-assembled equipment;
  - g) The testing of the re-assembled equipment, including acceptable values and tolerances of the measured/tested parameters; and
  - h) Some trouble-shooting methods if the required tolerances are not achieved.

The trouble-shooting portion of the videotape or DVD shall record the normal/expected values of equipment performance, plus techniques and tips to analyse the cause of any abnormalities, and how to correct them. The videotape(s) or DVD's shall be recorded on a VHS (PAL-C) system and DVD.

#### **4.10 Spares**

Spares will normally be purchased at the same time that orders are placed for circuit-breakers. The quantity of spares required will be determined by City Power. Prices for spares quoted in the pricing schedules for delivery to any of the specified destinations shall remain valid for the duration of the contract period and will be subject to the same Contract Price Adjustment formula as applied to the circuit-breakers. The supplier shall present a list of the minimum recommended spares together with prices in the pricing schedules for the circuit-breakers concerned. Spares shall be identified by a unique number, which shall be cross-referenced with the instruction manual. Spares shall be packed in separate cases, clearly labeled and consigned to City Power. Each spares item shall be provided with a metal label bearing the appropriate identification. A parts list shall be provided with each consignment of spares, clearly identifying each item by description, identification number and quantity supplied. City Power's order or contract number shall appear on the cases containing spares. Care shall be taken to ensure that spares are protectively packed for satisfactory long-term storage (a maximum of two years). Spares will usually be stored indoors, but bulky items such as spare bushings, post insulators and mechanisms, will be stored outdoors.

Because the supplier represents the OEM, he/she shall be responsible for ensuring the continued availability of spare parts required for maintenance for a period of not less than thirty years from the date of final manufacture of the switchgear and control-gear.

**Availability of spares:** The supplier shall undertake to supply to City Power with all the necessary replacement parts for the circuit-breaker throughout its expected service life. If the manufacture of the specific make and type of circuit-breaker (or any of its replacement parts) is discontinued, City Power shall be advised in writing. Written advice shall also be provided for parts of the equipment (e.g. SF<sub>6</sub> monitoring equipment) that the supplier obtains from a third party (sub-supplier). In this situation, the supplier shall supply the following information to City Power:

- a) All design data;
- b) All material characteristics and parameters;
- c) All testing information (parameters, equipment, methods, criteria, etc.);
- d) All manufacturing information; and
- e) All relevant working drawings and information.

-----

This information shall be supplied to City Power in a legible and acceptable format in English when notice of discontinuation of the circuit-breaker or any of its replacement parts is given. In this case, City Power shall be able to make alternative arrangements to obtain the necessary replacement parts. Another option is to pool spare parts: the supplier shall state his/her spares availability philosophy at the time of tendering.

#### **4.11 Maintenance training**

The supplier shall be able to offer local training facilities in South Africa for training City Power's personnel or appointed contractor in the operation and maintenance of the supplied equipment. Persons responsible for such training shall be trained, competent and certified by the OEM. A detailed breakdown of training programmes for the particular equipment shall be submitted at the tendering stage.

**Note:** This maintenance training is an option to be taken up by City Power if required.

#### **4.12 Maintenance contract**

The supplier is encouraged to offer a maintenance contract for major maintenance of its equipment. The scope of work for such maintenance shall be clearly defined for the various possible services – that is, it shall include a breakdown in man-hours and cost of spare parts. The maintenance crew shall be fully instructed in maintenance at the OEM's works. The supplier shall submit a competency file with all the names and the qualifications of the maintenance crew to City Power. The training and accreditation of the persons undertaking site erection work shall be the responsibility of the supplier. *Also see section 4.5.* A detailed description of the service organisation of the supplier and servicing facilities shall be given at the tendering stage. The same shall apply to the OEM's service organisation and service facilities.

**Note:** This maintenance contract is an option to be taken up by City Power.

#### **4.13 Drawings**

The following drawings shall be submitted for the first time at the tendering stage. These drawings shall comply with Technology Service Substation Work Group requirements. Upon receipt of the contract, the supplier shall be resubmit the drawings as contractual drawings for final approval by City Power. All drawings shall be clearly marked with the relevant City Power reference number.

##### **4.13.1 Outline and general arrangement drawings**

The following minimum information shall be included:

- a) Leading dimensions, i.e. phase-to-phase spacing, minimum phase-to-phase clearances, distance to main-terminals, distance to lowest part of insulation above ground (not less than 2 500 mm), distance to nearest live portion above ground, distance above ground to top of operating mechanism, dimensions of mechanism, overall height, width and depth of circuit-breaker;
- b) Foundation and/or holding-down details;
- c) Details of main terminals and earthing terminals;

- 
- d) Maximum permissible loading on main terminals (with directions) expressed in Newton's (N);
  - e) Mass of circuit-breaker in kilograms, which shall include the empty mass, mass and description of heaviest component, total mass of circuit-breaker ready for service and mass of filling medium;
  - f) Any special trenches or steelwork required between phases;
  - g) Dimensioned outline and general arrangement drawings including foundation details of circuit breaker offered; and
  - h) Where applicable, dimensioned outline and general arrangement drawing including foundation details of the supporting structures offered, if not included in the above.

#### **4.13.2 Schematic wiring diagram**

Contacts shall be shown with the main contacts in the open position, relays in the de-energised condition or springs discharged. The state of these items shall be clearly described in the schematic wiring diagram. Diagrams shall show the relative timing of main and auxiliary contacts and if applicable, operating levels of pressure switches, reducing and safety valves on increasing and decreasing pressure. Drawings shall be labeled in English.

## **5 INSPECTION AND TESTS**

All inspections and tests shall be controlled by means of product/process quality plans.

**Test reports/certificates:** Single copies of type-test reports/certificates and a typical routine test report/certificate shall be submitted to City Power at the time of tendering as a necessary part of the technical evaluation process. Two copies of the routine test reports/certificates, approved by City Power's representative, shall be submitted with dispatch of each circuit-breaker from the OEM's works. The test certificates shall be in English.

**Inspection and witnessing of tests:** City Power reserves the right to appoint a representative to inspect the circuit-breakers prior to release for shipment, or at any stage of manufacture, and to be present at any tests. At the tendering stage, the supplier shall submit the quality control plans to City Power, indicating all inspection hold points. City Power or representative appointed by City Power shall witness the final acceptance tests. The supplier shall make due allowance for these activities in the manufacturing programme and, to avoid delays, shall give at least 14 days' advance notice of the date of inspection or final acceptance tests.

City Power will not accept late delivery on the basis of inspection delays.

### **5.1 Type testing**

City Power requires complete type-test data, together with details of the test facilities and test conditions. If type-test data is not available, an indication of when the required test will be carried out shall be given. Regardless of whether type-test data is submitted at the tendering stage, the cost of carrying out each type-test shall be given in the pricing schedules. If, in the opinion of City Power, repeat or new type-tests are necessary, the costs of these tests will be taken into account in the evaluation of tenders.

Type testing shall be carried out in accordance with IEC recommendations wherever possible.

---

## **5.2 Routine testing**

### **5.2.1 General**

Routine testing shall be carried out in the OEM's works on all circuit-breakers. A test certificate shall be issued stating the tests performed results; identification of the equipment tested and shall be certified by an authorised City Power representative.

Circuit-breakers, which are subject to the provisions of the [Occupational Safety and Health Act](#) regarding pressure vessels, shall be provided with separate certificates for the associated pressure vessels. These certificates shall be issued by an independent inspection authority approved by City Power. The costs of such an inspection authority appointment shall be borne by the supplier. The supplier shall supply to the appointed inspection authority calculation sheets, design drawings and welding procedures of all pressure vessels for approval before manufacture commences. In addition, copies of sub-orders for bought-out vessels or works orders shall be supplied to the appointed authority, if manufactured internally. Sufficient proof shall be provided that all welders employed in the fabrication of pressure vessels are adequately qualified and that their qualifications are valid. All the routine test data shall be stored at the OEM's works as a reference for future enquiries.

### **5.2.2 Routine tests**

#### **5.2.2.1 Operation tests**

The following operational tests shall be performed:

- a) A minimum of twenty normal operations;
- b) Operations at maximum and minimum control voltage (all closing and tripping systems);
- c) If applicable, at least four trip-free operations; and
- d) Check of anti-pumping function.

The following quantities shall be measured and recorded (where applicable):

- a) Closing and opening velocities;
- b) Closing and opening times;
- c) Time taken to recharge the mechanism, restore pressures and pressure fall following an O, C and OCO operation;
- d) Synchronism across phases and between breaks of phases for an O, C and OCO operation;
- e) Timing tests on each type of auxiliary switch contact in relation to the main contacts; and
- f) Settings of pressure switches and gas densimeters.

#### **5.2.2.2 Wiring checks**

The secondary wiring shall be verified in accordance with the approved wiring diagram. The resistance of heater circuits, trip and close coils, coils of contactors shall be checked.

#### **5.2.2.3 Voltage tests**

Tests shall be performed on the main and secondary circuits in accordance with IEC 60060-1.

---

#### **5.2.2.4 Resistance of main circuit**

The main circuit shall be tested in accordance with IEC 60060-1.

#### **Miscellaneous tests**

Other tests (e.g. SF<sub>6</sub> gas leakage rates) shall be performed by the OEM as part of quality control.

### **5.3 Pre-commissioning tests**

#### **5.3.1 Timing characteristics**

Circuit-breakers do not have to be high-voltage tested at site unless this is specifically called for. The circuit-breaker shall be checked for normal behavior during tripping, closing and recharging of the operating mechanism. The supplier shall carry out the following pre-commissioning tests after erecting the circuit-breaker at site. These tests shall be performed for all circuit-breakers up to 132 kV. For reasons of compatibility with City Power's measuring equipment, one of the following types of equipment shall be used to perform the timing tests and measure/record the travel curves:

- a) CSD Hathaway - CBT-4 Instrument, Ireland and
- b) Programma Elektrik AB - TM 1600 Instrument, Sweden.

The software used shall be compatible with any one of the two devices, and will be specified when ordering the circuit-breaker. The choice may depend on the where the circuit-breaker will be used.

**Function time tests main and auxiliary contacts:** The following operating times of the *main contacts and the auxiliary contacts of all phases* shall be measured:

*Nominal* control voltage and *filling* pressure of SF<sub>6</sub> (if applicable):

Close: 2 operations

Open: 1 operation

Close-Open: 1 operation

Open-Close-Open: 1 operation

Minimum control voltage and warning pressure of SF<sub>6</sub> (if applicable):

Close: 2 operations

Open: 1 operation

Close-Open: 1 operation

Open-Close-Open: 1 operation

Each sequence shall be performed using the close coil and trip coil I (main) as well as the close coil and trip coil II (backup). The supplier shall use his own variable DC voltage supply and operating time-measuring equipment, including all the cabling, tools for these tests. The operating time of all the main contacts shall be measured. For the auxiliary contacts, it is sufficient to measure the operating time of one normally open and one normally closed contact in each phase. This can be done by using the dedicated, so-called "condition-monitoring contacts". The measured times for nominal coil control voltage shall be within ± 2% of the times, as specified on the circuit-breaker pass sheet supplied by the OEM. This includes measured times at lowest coil-control voltage. The anti-pumping protection of the circuit-breaker shall be checked by simultaneously giving close and open commands to the circuit-

breaker during a time that equals the mechanism recharging time plus 30 s, when the circuit-breaker is in the open position. The minimum coil-control voltage for the anti-pumping relay shall also be measured.

For each measurement of the operating time, a recording shall be made of each individual operating coil current – namely close, trip I and trip II. The resolution of the function times shall be a maximum of 0,2 ms.

In the case of spring closing mechanisms:

The closing spring charging time shall be measured. The maximum motor current in the spring charging process shall be measured as well as the steady state motor current. The results shall be within  $\pm 2\%$  of the circuit-breaker pass sheet results supplied by the OEM.

The mechanism-charging parameters for all the sequences as described above shall be measured. The motor running times shall be checked at nominal voltage and at 80% of nominal voltage. All the functional values shall meet City Power's approved tolerance ranges, valid for this type of circuit-breaker. Reasons for differences between these measurements and the results of the tests as they were carried out at the OEM's works (the circuit-breaker pass sheet) shall be clearly stated and corrections shall be made.

### **5.3.2 Contact travel curves**

The contact travel traces (including velocity and acceleration) record the instantaneous positions of the circuit-breaker's main contact during an operation. The travel curves for each phase shall be measured during pre-commissioning tests.

The following measuring results shall be provided:

- a) The total travel (in mm);
- b) The over-travel (in mm);
- c) The rebound (in mm);
- d) The under-travel (in mm);
- e) The contact penetration (in mm);
- f) Moving-contact or operating rod position at the time of make or break;
- g) Anomalies which are evident from the trace;
- h) The average speed on closing (in  $\text{ms}^{-1}$ ); and
- i) The average speed on opening (in  $\text{ms}^{-1}$ ).

The supplier shall supply all necessary equipment and expertise for these measurements and recordings. In the test report, the specifications of the transducers shall be given. The location of the transducers on the circuit-breakers shall be clearly indicated in the test report. Any variances from the routine test results obtained at the factory shall be clarified.

### **5.3.3 Resistance of the main contacts**

**Contact resistance:** The DC steady-state contact resistance shall be measured separately for each main contact. If this is not possible, the overall main contact resistance for the particular phase shall be measured. A DC current source of at least 100 A shall be used to perform this test. The results shall be expressed in  $\mu\Omega$ . The resolution shall be at least 1  $\mu\Omega$ .

**Dynamic contact resistance:** The dynamic contact resistance shall be measured during a close and open operation of the circuit-breaker. This shall be done for each main contact separately.

-----

If the separate phases of the circuit-breaker have multiple interrupter chambers, then the measurement of one chamber per phase is sufficient. A resolution of  $\pm 1 \mu\Omega$  is required. A detailed diagram of the measurement set-up shall be given (sketched) in the pre-commissioning test report. If any difficulties have occurred during erection or commissioning, this shall be clearly stated in the pre-commissioning test report.

#### **5.3.4 Pre-commissioning test report**

All pre-commissioning testing performed by an accredited installer shall be witnessed by the appointed City Power official. A circuit-breaker pre-commissioning test report shall be submitted to City Power, comprising the following parts:

- a) After the measurements at the substation site, a hand-written pre-commissioning test report shall be handed over to the substation supervisor/operator;
- b) Within three weeks of the pre-commissioning tests, the supplier to City Power shall submit an official report (two copies to City Power); and
- c) In addition to the official report that must be submitted, a test report on a standard 1,44 MB 3,5" stiffy disk/CD shall be provided with each individual circuit-breaker. The software used shall be compatible with one of the two previously mentioned measuring devices. This disk shall be submitted to City Power.

All the measured values shall be clearly stated in the report as well as the following:

The measuring instruments used shall be specified:

- a) Make and type of instruments;
- b) Serial numbers of instruments;
- c) Methods of triggering;
- d) Measuring methods;
- e) The accuracy of the instruments; and
- f) Calibration certificates of the used measuring instruments.

The circuit-breaker data:

- a) Make and type;
- b) Serial numbers of poles and mechanisms;
- c) The name of the substation and section;
- d) Circuit-breaker identification and application;
- e) Date of commissioning;
- f) Date and time of measuring; and
- g) Rated voltage, current and breaking capacity.

Clear copies of the complete printouts of the timing, dynamic resistance and travel measurements shall be attached to the official report. The names of all parties concerned shall be clearly stated in the report. If the measured values differ from the values as they were measured in the manufacturer's plant, an interpretation shall be given and, if City Power deems it necessary, the situation shall be corrected by the supplier. If the circuit-breaker is found to be faulty during the tests, a fault report shall be completed in accordance with IEC 61208 in addition to the pre-commissioning test report.

---

**Annex A – Bibliography**

*Eskom document SCSSCAAP9: Rev 1, Corrosion protection specification for distribution equipment manufactured from 3CR12 stainless steel and mild steel (Draft).*

*Eskom document SCSSCAAI5: Rev 2, Distribution voltage transformers: specific requirements for voltage manufactured in accordance with NRS 030, up to and including 132 kV.*

*Eskom Document: SCSSCABC2: Rev 5, Distribution group's specific requirements for 132-kV and 66-kV circuit-breakers*

---

**Annex B – Revision information**

<b>DATE</b>	<b>REV. NO.</b>	<b>NOTES</b>
Nov 2005	0	First issue

**Annex C – Technical schedules A and B**

**for**

**33 kV post-type vacuum circuit breakers**

**Schedule A: Purchaser's specific requirements**

**Schedule B: Guarantees and technical particulars of equipment offered**

Item	Description	Schedule A	Schedule B
<b>1</b>	<b>General</b>	XXXX	XXXX
<b>1.1</b>	<b>When erection is not required</b>	XXXX	XXXX
	a) Access to stores by	Road	XXXX
	b) Offloading from transport	Yes	XXXX
<b>1.2</b>	<b>When erection is required</b>	XXXX	XXXX
	a) Access to site by	Road	XXXX
	b) Offloading from transport	Yes	XXXX
	c) Crane made available by City Power for offloading	No	XXXX
	d) Distance from offloading point to operating position	m 300	XXXX
	e) Nature of ground to be traversed	Soft earth	XXXX
	f) Rise fall	m 3	XXXX
	g) Supply and erection of support structures required?	Yes	XXXX
	h) Construction power supply available?	No	XXXX
<b>2</b>	<b>Details of circuit-breakers</b>	XXXX	XXXX
<b>2.1</b>	<b>Circuit-breaker rating (to IEC 62271-100)</b>	XXXX	XXXX
	a) Nominal voltage ( $U_n$ )	kV 33	
	b) Normal load current	A 1600	
	c) Nominal short-time withstand current duration	s 3	
	d) Nominal short-time withstand current (thermal)	kA 25	
	e) Rated peak withstand current (dynamic)	kA 63	
	f) Operating duty cycle where	O-t-CO-t'-CO	
	t = 0,3 s		
	t' = 3 min		

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE  
**CP\_TSSPEC\_145**

REV  
**0**

PAGE **39** OF **67**

Item	Description	Schedule A	Schedule B
	g) Cooling time before duty is repeated	min XXXX	
	h) Rated insulation level	kV 200	
<b>2.2</b>	<b>System conditions of service</b>	XXXX	XXXX
	a) Maximum system voltage (Um)	kV 36	
	b) Number of phases	3	
	c) Nominal system frequency	Hz 50	
<b>2.3</b>	<b>Site conditions of service</b>		
	a) Altitude above sea level	m Up to 1 800	
	b) Ambient air temperature range	XXXX	XXXX
	Maximum	°C +40	
	Minimum	°C -10	
	Highest average daily maximum	°C +35	
	Lowest average daily maximum	°C +5	
	Maximum average daily variation	°C 25	
	c) Icing conditions	mm 10	
	d) Humidity (relative)	XXXX	XXXX
	Minimum	% 5	
	Maximum	% 99	
	Average	% 50	
	e) Solar radiation	XXXX	XXXX
	Maximum solar radiation intensity	W/m <sup>2</sup> 1 100	
	f) Wind loading	XXXX	XXXX
	Basic design velocity	km/hr 115	
	Maximum wind speed (gusting)	km/hr 144	
	Wind pressure	Pascal 1 000	
	g) Lightning ground flash density	flashes per km <sup>2</sup> / year Up to 8	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**40**

OF

**67**

Item	Description	Schedule A	Schedule B
	h) Pollution	Very heavy	
	i) Climatic conditions	Summer rain	
	j) Seismic data	Not a normal requirement	
<b>2.4</b>	<b>Type of circuit-breakers</b>	XXXX	XXXX
	Vacuum interrupting	XXXX	
<b>2.5</b>	<b>Manufacturer (OEM)</b>	XXXX	
<b>2.6</b>	<b>Type designation</b>	XXXX	
<b>2.7</b>	<b>Operating mechanism</b>	XXXX	XXXX
	a) Opening	spring	
	b) Closing	spring	
	c) Number of mechanisms per circuit breaker?	One (3-pole mech)	
<b>2.8</b>	<b>Circuit interrupting chambers</b>	XXXX	XXXX
	a) Number in series per phase	1	
	b) Length of each series break	mm	XXXX
	c) Contact resistance at 20 °C	μΩ	XXXX
	d) Current used to determine this contact resistance	A DC	Minimum 100
	e) Length of arcing contact	mm	XXXX
	f) Average contact velocity		XXXX
	On opening	m/s	XXXX
	On closing	m/s	XXXX
<b>2.9</b>	<b>Maximum total break time not to exceed (on 50- Hz basis)</b>	ms	60
<b>2.10</b>	<b>Maximum opening time</b>		XXXX
	a) Main contacts	ms	XXXX
	b) Auxiliary contacts	ms	XXXX

Item	Description	Schedule A	Schedule B
	<b>At minimum trip-coil voltage:</b>	V	77
	a) Main contacts	ms	XXXX
	b) Auxiliary contacts	ms	XXXX
	<b>Main contact timing spread</b>		XXXX
	a) Interpole opening	ms	XXXX
	b) Interpole closing	ms	XXXX
	c) Intrapole opening	ms	XXXX
	d) Intrapole closing	ms	XXXX
<b>2.11</b>	<b>Maximum closing time</b>		XXXX
	At nominal close coil voltage:	V	110
	a) Main contacts	ms	XXXX
	b) Auxiliary contacts	ms	XXXX
	<b>At minimum close coil voltage</b>	V	77
	a) Main contacts	ms	XXXX
	b) Auxiliary contacts	ms	XXXX
<b>2.12</b>	<b>Auto-reclosing</b>		XXXX
	a) Type of auto-reclosing 3-pole or 1-pole		3
	b) Minimum dead time	m.s	300
	c) Number of reclosures		1
<b>2.13</b>	<b>Maximum over-voltage factor for conditions detailed under switching conditions in IEC 62271-100</b>	p.u	2,5
<b>2.14</b>	<b>Switching performance of unloaded transmission lines</b>	To IEC 60050-604	
<b>2.15</b>	<b>Electrical tripping</b>		XXXX
	a) Nominal control voltage	V	110
	b) Number of trip coils per mechanism (main and backup)		2
	c) Maximum power drain by trip coil at nominal	W	500

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE  
**CP\_TSSPEC\_145**

REV  
**0**

PAGE **42** OF **67**

Item	Description	Schedule A	Schedule B
<b>2.16</b>	<b>Electrical closing</b>	XXXX	XXXX
	a) Nominal control voltage <span style="float: right;">V</span>	110	
	b) Number of close coils per mechanism	1	
	c) Maximum power drain by close coil at nominal voltage <span style="float: right;">W</span>	500	
<b>2.17</b>	<b>Spring mechanisms</b>	XXXX	XXXX
	a) Hand recharge	Yes	
	b) Motor recharge	Yes	
	c) Motor voltage <span style="float: right;">V</span>	110	
	d) Rated power of motor <span style="float: right;">W</span>	XXXX	
	e) Maximum starting current drawn by motor <span style="float: right;">A</span>	XXXX	
	f) Steady-state current of motor <span style="float: right;">A</span>	XXXX	
	g) Mechanism resetting time	XXXX	XXXX
	At 80% control voltage <span style="float: right;">s</span>	XXXX	
	At 100% control voltage <span style="float: right;">s</span>	XXXX	
	h) Spare spring-drive limit switch contacts per mechanism to be provided	XXXX	XXXX
	normally open (when closing spring discharged)	3	
	normally closed (when closing spring discharged)	2	
	i) Closing mechanism energy <span style="float: right;">kJ</span>	XXXX	
	j) Minimum % "excess energy" stored in closing spring to ensure proper closing at routine test <span style="float: right;">%</span>	XXXX	
<b>2.18</b>	<b>Phase discrepancy (PD) detection</b>	XXXX	XXXX
	a) Method	Electrical	
	b) PD time relay provided by	Supplier	
	c) Minimum setting permissible on PD time relay <span style="float: right;">ms</span>	XXXX	
<b>2.19</b>	<b>Auxiliary switches</b>	XXXX	XXXX
	a) OEM	XXXX	
	b) Type designation	XXXX	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**43**

OF

**67**

Item	Description		Schedule A	Schedule B
	N/O & N/C contact reference positions Circuit-breaker		Circuit-breaker open, spring discharged, All Auxiliary relays deenergised.	
	Breaker auxiliary 'a' and 'b' contacts	N/O	4	
		N/C	4	
	Spring-limit-switch contacts	N/O	1	
		N/C	3	
<b>2.21</b>	<b>Each main terminal to be an aluminium flat pad of the following dimensions</b>		XXXX	XXXX
	a) Number of holes/pitch	mm	8/50	
	b) Diameter	mm	14	
<b>3</b>	<b>Insulation and clearances</b>		XXXX	XXXX
<b>3.1</b>	<b>OEM of porcelain/polymer insulators</b>		XXXX	XXXX
<b>3.2</b>	<b>Lightning impulse wave (1,2/50 <math>\mu</math>s) withstand voltage to earth</b>	kVpeak	200	
<b>3.3</b>	<b>Power frequency (wet) 60 s withstand voltage to earth</b>	kVrms	70	
<b>3.4</b>	<b>Routine power frequency (dry) 60 s withstand voltage</b>		XXXX	XXXX
	a) To earth	kVrms	XXXX	
	b) Across open breaks	kVrms	XXXX	
<b>3.5</b>	<b>Minimum creepage distances over external insulation</b>		XXXX	XXXX
	a) To earth	mm/kV	31	
	b) In parallel with interrupting chambers	mm/kV	31	
	c) To earth (90° shadow to axis of insulator – IEC 60815)	mm	XXXX	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**44**

OF

**67**

Item	Description		Schedule A	Schedule B
3.6	<b>Preferred phase spacing</b>	mm	700	
3.7	<b>Electrical clearances</b>		XXXX	XXXX
	a) Between live portions of phases	mm	XXXX	
	b) Between live portions at system voltage and earth	mm	XXXX	
3.8	<b>Lowest point of insulation above ground level not to be less than</b>	mm	2 500	
3.9	<b>Radio influence voltage at 1 000 Hz</b>	µV	2 500 max.	
4	<b>Miscellaneous</b>		XXXX	XXXX
4.1	<b>Loading on foundations</b>		XXXX	XXXX
	a) Dead mass of three-phase circuit-breaker ready for service	kg	XXXX	
	b) Downwards reaction force to be added to (a) during opening	N	XXXX	XXXX
	closing	N	XXXX	
4.2	<b>Cubicle heating and ventilation</b>		XXXX	XXXX
	Electrical heating		XXXX	XXXX
	a) Supply voltage, 50 Hz	V AC	230	
	b) Power rating	W	Max 400	
4.3	<b>Secondary terminals, gland plate and cable connections</b>		XXXX	XXXX
	a) Terminal type		XXXX	
	b) OEM		XXXX	
	c) Undrilled gland plate of minimum usable area		100x150	
	d) Control cable type used by City Power	mm	PVC SWA	
	e) Minimum distance between terminal board	mm	>150	
4.4	<b>Testing authority certificates held to prove all ratings</b>		XXXX	
4.5	<b>Number of complete sets of instruction manuals and routine test results to be supplied with each circuit breaker</b>		One per circuit-breaker supplied in protective envelope inside mechanism door	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**45**

OF

**67**

Item	Description	Schedule A	Schedule B
<b>4.6</b>	<b>Number of complete sets of instruction manuals to be supplied on award of contract</b>	10	
<b>4.7</b>	<b>Terminal mechanical loading</b>	XXXX	XXXX
	Maximum continuous loading:	XXXX	XXXX
	Vertical <span style="float: right;">kN</span>	XXXX	
	30° to vertical <span style="float: right;">kN</span>	XXXX	
	60° to vertical <span style="float: right;">kN</span>	XXXX	
<b>4.8</b>	<b>Shunt capacitor-bank switching</b>	XXXX	XXXX
	Maximum "safe" inrush current <span style="float: right;">A</span>	XXXX	
	Maximum inrush frequency <span style="float: right;">Hz</span>	XXXX	
<b>4.9</b>	<b>Shunt-reactor switching</b>	XXXX	XXXX
	Critical arcing time window <span style="float: right;">ms</span>	XXXX	

Tender Number: \_\_\_\_\_

Tenderer's Authorised Signatory: \_\_\_\_\_  
Name in block letters    Signature

Full name of company: \_\_\_\_\_

**Annex C - Technical schedules A and B**

**for**

**33 kV post-type vacuum circuit breakers**

**Deviation schedule**

**Any deviations offered to this specification shall be listed below with reasons for deviation. In addition, evidence shall be provided that the proposed deviation will at least be more cost-effective than that specified by City Power.**

Item	Clause	Proposed deviation

Tender Number: \_\_\_\_\_

Tenderer's Authorised Signatory: \_\_\_\_\_  
Name in block letters                      Signature

Full name of company: \_\_\_\_\_

**Annex C - Technical schedules A and B**

**for**

**88 kV post-type SF<sub>6</sub> circuit breakers**

**Schedule A: Purchaser's specific requirements**

**Schedule B: Guarantees and technical particulars of equipment offered**

Item	Description	Schedule A	Schedule B
<b>1</b>	<b>General</b>	XXXX	XXXX
<b>1.1</b>	<b>When erection is not required</b>	XXXX	XXXX
	a) Access to stores by	Road	XXXX
	b) Offloading from transport	Yes	XXXX
<b>1.2</b>	<b>When erection is required</b>	XXXX	XXXX
	a) Access to site by	Road	XXXX
	b) Offloading from transport	Yes	XXXX
	c) Crane made available by City Power for offloading	No	XXXX
	d) Distance from offloading point to operating position	m 300	XXXX
	e) Nature of ground to be traversed	Soft earth	XXXX
	f) Rise fall	m 3	XXXX
	g) Erection on prepared steel support structures?	Yes	XXXX
	h) Construction power supply available?	No	XXXX
<b>2</b>	<b>Details of circuit-breakers</b>	XXXX	XXXX
<b>2.1</b>	<b>Circuit-breaker rating (to IEC 62271-100)</b>	XXXX	XXXX
	a) Nominal voltage (U <sub>n</sub> )	kV 88	
	b) Normal load current	A 2 500	
	c) Nominal short-time withstand current duration	s 3	
	d) Nominal short-time withstand current (thermal)	kA 31,5	
	e) Rated peak withstand current (dynamic)	kA 79	
	f) Operating duty cycle where	O-t-CO-t'-CO	
	t = 0,3 s		
	t' = 3 min		

Item	Description	Schedule A	Schedule B
	g) Cooling time before duty is repeated	min XXXX	
	h) Rated insulation level	kV 450	
<b>2.2</b>	<b>System conditions of service</b>	XXXX	XXXX
	a) Maximum system voltage (Um)	kV 100	
	b) Number of phases	3	
	c) Nominal system frequency	Hz 50	
<b>2.3</b>	<b>Site conditions of service</b>	XXXX	XXXX
	a) Altitude above sea level	m Up to 1 800	
	b) Ambient air temperature range	XXXX	XXXX
	Maximum	°C +40	
	Minimum	°C -10	
	Highest average daily maximum	°C +35	
	Lowest average daily maximum	°C +5	
	Maximum average daily variation	°C 25	
	c) Icing conditions	mm 10	
	d) Humidity (relative)	XXXX	XXXX
	Minimum	% 5	
	Maximum	% 99	
	Average	% 50	
	e) Solar radiation	XXXX	XXXX
	Maximum solar radiation intensity	W/m <sup>2</sup> 1 100	
	f) Wind loading	XXXX	XXXX
	Basic design velocity	km/hr 115	
	Maximum wind speed (gusting)	km/hr 144	
	Wind pressure	Pascal 1 000	
	g) Lightning ground flash density	flashes per km <sup>2</sup> / year Up to 8	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**49**

OF

**67**

Item	Description	Schedule A	Schedule B
	h) Pollution	Very heavy	
	i) Climatic conditions	Summer rain	
	j) Seismic data	Not a normal requirement	
<b>2.4</b>	<b>Type of circuit-breakers</b>	XXXX	XXXX
	a) SF <sub>6</sub> single pressure (puffer)	XXXX	
	b) SF <sub>6</sub> self-blast (auto-puffer)	XXXX	
<b>2.5</b>	<b>Manufacturer (OEM)</b>	XXXX	
<b>2.6</b>	<b>Type designation</b>	XXXX	
<b>2.7</b>	<b>Operating mechanism</b>	XXXX	XXXX
	a) Opening	spring	
	b) Closing	spring	
	c) Number of mechanisms per circuit breaker?	One (3-pole mech)	
<b>2.8</b>	<b>Circuit interrupting chambers</b>	XXXX	XXXX
	a) Number in series per phase	1	
	b) Length of each series break	mm	XXXX
	c) Contact resistance at 20 °C	μΩ	XXXX
	d) Current used to determine this contact resistance	A DC	Minimum 100
	e) Length of arcing contact	mm	XXXX
	f) Average contact velocity		XXXX
	On opening	m/s	XXXX
	On closing	m/s	XXXX
<b>2.9</b>	<b>Maximum total break time not to exceed (on 50- Hz basis)</b>	ms	60
<b>2.10</b>	<b>Maximum opening time</b>		XXXX
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX

Item	Description	Schedule A	Schedule B
	<b>At minimum trip-coil voltage:</b>	V	77
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX
	<b>Main contact timing spread</b>		XXXX
	▪ Interpole opening	ms	XXXX
	▪ Interpole closing	ms	XXXX
	▪ Intrapole opening	ms	XXXX
	▪ Intrapole closing	ms	XXXX
<b>2.11</b>	<b>Maximum closing time</b>		XXXX
	At nominal close coil voltage:	V	110
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX
	<b>At minimum close coil voltage</b>	V	77
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX
<b>2.12</b>	<b>Auto-reclosing</b>		XXXX
	a) Type of auto-reclosing 3-pole or 1-pole		3
	b) Minimum dead time	m.s	300
	c) Number of reclosures		1
<b>2.13</b>	<b>Maximum over-voltage factor for conditions detailed under switching conditions in IEC 62271-100</b>	p.u	2,5
<b>2.14</b>	<b>Switching performance of unloaded transmission lines</b>		To IEC 60050-604
<b>2.15</b>	<b>Electrical tripping</b>		XXXX
	a) Nominal control voltage	V	110
	b) Number of trip coils per mechanism (main and backup)		2
	c) Maximum power drain by trip coil at nominal	W	500

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE  
**CP\_TSSPEC\_145**

REV  
**0**

PAGE **51** OF **67**

Item	Description	Schedule A	Schedule B
<b>2.16</b>	<b>Electrical closing</b>	XXXX	XXXX
	a) Nominal control voltage <span style="float: right;">V</span>	110	
	b) Number of close coils per mechanism	1	
	c) Maximum power drain by close coil at nominal voltage <span style="float: right;">W</span>	500	
<b>2.17</b>	<b>Spring mechanisms</b>	XXXX	XXXX
	a) Hand recharge	Yes	
	b) Motor recharge	Yes	
	c) Motor voltage <span style="float: right;">V</span>	110	
	d) Rated power of motor <span style="float: right;">W</span>	XXXX	
	e) Maximum starting current drawn by motor <span style="float: right;">A</span>	XXXX	
	f) Steady-state current of motor <span style="float: right;">A</span>	XXXX	
	g) Mechanism resetting time	XXXX	XXXX
	At 80% control voltage <span style="float: right;">s</span>	XXXX	
	At 100% control voltage <span style="float: right;">s</span>	XXXX	
	h) Spare spring-drive limit switch contacts per mechanism to be provided	XXXX	XXXX
	normally open (when closing spring discharged)	3	
	normally closed (when closing spring discharged)	2	
	i) Closing mechanism energy <span style="float: right;">kJ</span>	XXXX	
	j) Minimum % "excess energy" stored in closing spring to ensure proper closing at routine test <span style="float: right;">%</span>	XXXX	
<b>2.18</b>	<b>Phase discrepancy (PD) detection</b>	XXXX	XXXX
	a) Method	Electrical	
	b) PD time relay provided by	Supplier	
	c) Minimum setting permissible on PD time relay <span style="float: right;">ms</span>	XXXX	
<b>2.19</b>	<b>Auxiliary switches</b>	XXXX	XXXX
	a) OEM	XXXX	
	b) Type designation	XXXX	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**52**

OF

**67**

Item	Description	Schedule A	Schedule B
	N/O & N/C contact reference positions Circuit-breaker	Circuit-breaker open, spring discharged SF6 low. All Auxiliary relays deenergised.	
	Alarm SF6 contacts. (if applicable)	N/O 0 N/C 2	
	Lockout – SF6 contacts (if applicable)	N/O 0 N/C 2	
	Breaker auxiliary 'a' and 'b' contacts	N/O 4 N/C 4	
	Spring-limit-switch contacts	N/O 1 N/C 3	
<b>2.20</b>	<b>SF6 and gas pressure monitoring</b>	Yes	
	a) Nominal filling pressure (at 20 °C)	kPa XXXX	
	b) Alarm levels		
	State 1: Non-urgent or warning (only refilling necessary)	kPa XXXX	
	State 2: Lockout (circuit-breaker to be taken out of circuit)	kPa XXXX	
	c) Mass of gas in complete circuit-breaker	kg XXXX	
	d) First filling to be supplied	Yes (when erection required)	
	e) Expected re-filling intervals due to natural loss of gas	years XXXX	
	f) Overpressure device on filling?	Yes	
	g) Pressure relief:	Yes	
	Number of relief devices	XXXX	
	Open/rupturing pressures	kPa XXXX	
	Type/material	XXXX	

Item	Description	Schedule A	Schedule B
	h) SF <sub>6</sub> density-monitoring device:	XXXX	
	OEM	XXXX	
	Type	XXXX	
	Temperature range °C	XXXX	
	Density range kg/m <sup>3</sup>	XXXX	
	Accuracy limit at: -10 °C	XXXX	
	+15 °C	XXXX	
	+25 °C	XXXX	
	+35 °C	XXXX	
	+40 °C	XXXX	
	Design principle	XXXX	
<b>2.21</b>	<b>Each main terminal to be an aluminium flat pad of the following dimensions</b>	XXXX	XXXX
	a) Number of holes/pitch mm	8/50	
	b) Diameter mm	14	
<b>3</b>	<b>Insulation and clearances</b>	XXXX	XXXX
<b>3.1</b>	<b>OEM of porcelain/polymer insulators</b>	XXXX	
<b>3.2</b>	<b>Lightning impulse wave (1,2/50 μs) withstand voltage to earth</b> kVpeak	450	
<b>3.3</b>	<b>Power frequency (wet) 60 s withstand voltage to earth</b> kVrms	150	
<b>3.4</b>	<b>Routine power frequency (dry) 60 s withstand voltage</b>	XXXX	XXXX
	a) To earth kVrms	XXXX	
	b) Across open breaks kVrms	XXXX	
<b>3.5</b>	<b>Minimum creepage distances over external insulation</b>	XXXX	XXXX
	a) To earth mm/kV	31	
	b) In parallel with interrupting chambers mm/kV	31	
	c) To earth (90° shadow to axis of insulator – IEC 60815) mm	XXXX	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**54**

OF

**67**

Item	Description		Schedule A	Schedule B
3.6	<b>Preferred phase spacing</b>	mm	1 700	
3.7	<b>Electrical clearances</b>		XXXX	XXXX
	a) Between live portions of phases	mm	XXXX	
	b) Between live portions at system voltage and earth	mm	XXXX	
3.8	<b>Lowest point of insulation above ground level not to be less than</b>	mm	2 500	
3.9	<b>Radio influence voltage at 1 000 Hz</b>	µV	2 500 max.	
4	<b>Miscellaneous</b>		XXXX	XXXX
4.1	<b>Loading on foundations</b>		XXXX	XXXX
	a) Dead mass of three-phase circuit-breaker ready for service	kg	XXXX	
	b) Downwards reaction force to be added to (a) during opening	N	XXXX	XXXX
	closing	N	XXXX	
4.2	<b>Cubicle heating and ventilation</b>		XXXX	XXXX
	Electrical heating		XXXX	XXXX
	a) Supply voltage, 50 Hz	V AC	230	
	b) Power rating	W	Max 400	
4.3	<b>Secondary terminals, gland plate and cable connections</b>		XXXX	XXXX
	a) Terminal type		XXXX	
	b) OEM		XXXX	
	c) Undrilled gland plate of minimum usable area		100x150	
	d) Control cable type used by City Power	mm	PVC SWA	
	e) Minimum distance between terminal board	mm	>150	
4.4	<b>Testing authority certificates held to prove all ratings</b>		XXXX	
4.5	<b>Number of complete sets of instruction manuals and routine test results to be supplied with each circuit breaker</b>		One per circuit-breaker supplied in protective envelope inside mechanism door	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**55**

OF

**67**

Item	Description	Schedule A	Schedule B
<b>4.6</b>	<b>Number of complete sets of instruction manuals to be supplied on award of contract</b>	10	
<b>4.7</b>	<b>Terminal mechanical loading</b>	XXXX	XXXX
	Maximum continuous loading:	XXXX	XXXX
	Vertical <span style="float: right;">kN</span>	XXXX	
	30° to vertical <span style="float: right;">kN</span>	XXXX	
	60° to vertical <span style="float: right;">kN</span>	XXXX	
<b>4.8</b>	<b>Shunt capacitor-bank switching</b>	XXXX	XXXX
	Maximum "safe" inrush current <span style="float: right;">A</span>	XXXX	
	Maximum inrush frequency <span style="float: right;">Hz</span>	XXXX	
<b>4.9</b>	<b>Shunt-reactor switching</b>	XXXX	XXXX
	Critical arcing time window <span style="float: right;">ms</span>	XXXX	

Tender Number: \_\_\_\_\_

Tenderer's Authorised Signatory: \_\_\_\_\_  
Name in block letters    Signature

Full name of company: \_\_\_\_\_

**Annex C - Technical schedules A and B**

**for**

**88 kV post-type SF6 circuit breakers**

**Deviation schedule**

**Any deviations offered to this specification shall be listed below with reasons for deviation. In addition, evidence shall be provided that the proposed deviation will at least be more cost-effective than that specified by City Power.**

Item	Clause	Proposed deviation

Tender Number: \_\_\_\_\_

Tenderer's Authorised Signatory: \_\_\_\_\_  
Name in block letters                      Signature

Full name of company: \_\_\_\_\_

**Annex C - Technical schedules A and B**

**for**

**132 kV post-type SF6 circuit breakers**

**Schedule A: Purchaser's specific requirements**

**Schedule B: Guarantees and technical particulars of equipment offered**

Item	Description	Schedule A	Schedule B
<b>1</b>	<b>General</b>	XXXX	XXXX
<b>1.1</b>	<b>When erection is not required</b>	XXXX	XXXX
	a) Access to stores by	Road	XXXX
	b) Offloading from transport	Yes	XXXX
<b>1.2</b>	<b>When erection is required</b>	XXXX	XXXX
	a) Access to site by	Road	XXXX
	b) Offloading from transport	Yes	XXXX
	c) Crane made available by City Power for offloading	No	XXXX
	d) Distance from offloading point to operating position	m 300	XXXX
	e) Nature of ground to be traversed	Soft earth	XXXX
	f) Rise fall	m 3	XXXX
	g) Supply and erection of support structures required?	Yes	XXXX
	h) Construction power supply available?	No	XXXX
<b>2</b>	<b>Details of circuit-breakers</b>	XXXX	XXXX
<b>2.1</b>	<b>Circuit-breaker rating (to IEC 62271-100)</b>	XXXX	XXXX
	a) Nominal voltage (U <sub>n</sub> )	kV 132	
	b) Normal load current	A 2 500	
	c) Nominal short-time withstand current duration	s 3	
	d) Nominal short-time withstand current (thermal)	kA 31,5	
	e) Rated peak withstand current (dynamic)	kA 79	
	f) Operating duty cycle where	O-t-CO-t'-CO	
	t = 0,3 s		
	t' = 3 min		

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**58**

OF

**67**

Item	Description	Schedule A	Schedule B
	g) Cooling time before duty is repeated	min	XXXX
	h) Rated insulation level	kV	550
<b>2.2</b>	<b>System conditions of service</b>	XXXX	XXXX
	a) Maximum system voltage (Um)	kV	145
	b) Number of phases		3
	c) Nominal system frequency	Hz	50
<b>2.3</b>	<b>Site conditions of service</b>	XXXX	XXXX
	a) Altitude above sea level	m	Up to 1 800
	b) Ambient air temperature range		XXXX
	Maximum	°C	+40
	Minimum	°C	-10
	Highest average daily maximum	°C	+35
	Lowest average daily maximum	°C	+5
	Maximum average daily variation	°C	25
	c) Icing conditions	mm	10
	d) Humidity (relative)		XXXX
	Minimum	%	5
	Maximum	%	99
	Average	%	50
	e) Solar radiation		XXXX
	Maximum solar radiation intensity	W/m <sup>2</sup>	1 100
	f) Wind loading		XXXX
	Basic design velocity	km/hr	115
	Maximum wind speed (gusting)	km/hr	144
	Wind pressure	Pascal	1 000
	g) Lightning ground flash density	flashes per km <sup>2</sup> / year	Up to 8

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**59**

OF

**67**

Item	Description	Schedule A	Schedule B
	h) Pollution	Very heavy	
	i) Climatic conditions	Summer rain	
	j) Seismic data	Not a normal requirement	
<b>2.4</b>	<b>Type of circuit-breakers</b>	XXXX	XXXX
	a) SF <sub>6</sub> single pressure (puffer)	XXXX	
	b) SF <sub>6</sub> self-blast (auto-puffer)	XXXX	
<b>2.5</b>	<b>Manufacturer (OEM)</b>	XXXX	
<b>2.6</b>	<b>Type designation</b>	XXXX	
<b>2.7</b>	<b>Operating mechanism</b>	XXXX	XXXX
	a) Opening	spring	
	b) Closing	spring	
	c) Number of mechanisms per circuit breaker?	One (3-pole mech)	
<b>2.8</b>	<b>Circuit interrupting chambers</b>	XXXX	XXXX
	a) Number in series per phase	1	
	b) Length of each series break	mm	XXXX
	c) Contact resistance at 20 °C	μΩ	XXXX
	d) Current used to determine this contact resistance	A DC	Minimum 100
	e) Length of arcing contact	mm	XXXX
	f) Average contact velocity		XXXX
	On opening	m/s	XXXX
	On closing	m/s	XXXX
<b>2.9</b>	<b>Maximum total break time not to exceed (on 50- Hz basis)</b>	ms	60
<b>2.10</b>	<b>Maximum opening time</b>		XXXX
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX

Item	Description	Schedule A	Schedule B
	<b>At minimum trip-coil voltage:</b>	V	77
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX
	<b>Main contact timing spread</b>		XXXX
	▪ Interpole opening	ms	XXXX
	▪ Interpole closing	ms	XXXX
	▪ Intrapole opening	ms	XXXX
	▪ Intrapole closing	ms	XXXX
<b>2.11</b>	<b>Maximum closing time</b>		XXXX
	At nominal close coil voltage:	V	110
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX
	<b>At minimum close coil voltage</b>	V	77
	▪ Main contacts	ms	XXXX
	▪ Auxiliary contacts	ms	XXXX
<b>2.12</b>	<b>Auto-reclosing</b>		XXXX
	a) Type of auto-reclosing 3-pole or 1-pole		3
	b) Minimum dead time	m.s	300
	c) Number of reclosures		1
<b>2.13</b>	<b>Maximum over-voltage factor for conditions detailed under switching conditions in IEC 62271-100</b>	p.u	2,5
<b>2.14</b>	<b>Switching performance of unloaded transmission lines</b>		To IEC 60050-604
<b>2.15</b>	<b>Electrical tripping</b>		XXXX
	a) Nominal control voltage	V	110
	b) Number of trip coils per mechanism (main and backup)		2
	c) Maximum power drain by trip coil at nominal	W	500

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**61**

OF

**67**

Item	Description	Schedule A	Schedule B
<b>2.16</b>	<b>Electrical closing</b>	XXXX	XXXX
	a) Nominal control voltage <span style="float: right;">V</span>	110	
	b) Number of close coils per mechanism	1	
	c) Maximum power drain by close coil at nominal voltage <span style="float: right;">W</span>	500	
<b>2.17</b>	<b>Spring mechanisms</b>	XXXX	XXXX
	a) Hand recharge	Yes	
	b) Motor recharge	Yes	
	c) Motor voltage <span style="float: right;">V</span>	110	
	d) Rated power of motor <span style="float: right;">W</span>	XXXX	
	e) Maximum starting current drawn by motor <span style="float: right;">A</span>	XXXX	
	f) Steady-state current of motor <span style="float: right;">A</span>	XXXX	
	g) Mechanism resetting time	XXXX	XXXX
	At 80% control voltage <span style="float: right;">s</span>	XXXX	
	At 100% control voltage <span style="float: right;">s</span>	XXXX	
	h) Spare spring-drive limit switch contacts per mechanism to be provided	XXXX	XXXX
	normally open (when closing spring discharged)	3	
	normally closed (when closing spring discharged)	2	
	i) Closing mechanism energy <span style="float: right;">kJ</span>	XXXX	
	j) Minimum % "excess energy" stored in closing spring to ensure proper closing at routine test <span style="float: right;">%</span>	XXXX	
<b>2.18</b>	<b>Phase discrepancy (PD) detection</b>	XXXX	XXXX
	a) Method	Electrical	
	b) PD time relay provided by	Supplier	
	c) Minimum setting permissible on PD time relay <span style="float: right;">ms</span>	XXXX	
<b>2.19</b>	<b>Auxiliary switches</b>	XXXX	XXXX
	a) OEM	XXXX	
	b) Type designation	XXXX	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**62**

OF

**67**

Item	Description	Schedule A	Schedule B
	N/O & N/C contact reference positions Circuit-breaker	Circuit-breaker open, spring discharged SF6 low. All Auxiliary relays de-energized.	
	Alarm SF6 contacts. (if applicable)	N/O 0 N/C 2	
	Lockout – SF6 contacts (if applicable)	N/O 0 N/C 2	
	Breaker auxiliary 'a' and 'b' contacts	N/O 4 N/C 4	
	Spring-limit-switch contacts	N/O 1 N/C 3	
<b>2.20</b>	<b>SF6 and gas pressure monitoring</b>	Yes	
	a) Nominal filling pressure (at 20 °C)	kPa XXXX	
	b) Alarm levels	XXXX	XXXX
	State 1: Non-urgent or warning (only refilling necessary)	kPa XXXX	
	State 2: Lockout (circuit-breaker to be taken out of circuit)	kPa XXXX	
	c) Mass of gas in complete circuit-breaker	kg XXXX	
	d) First filling to be supplied	Yes (when erection required)	
	e) Expected re-filling intervals due to natural loss of gas	years XXXX	
	f) Overpressure device on filling?	Yes	
	g) Pressure relief:	Yes	
	Number of relief devices	XXXX	
	Open/rupturing pressures	kPa XXXX	
	Type/material	XXXX	

Item	Description	Schedule A	Schedule B
	h) SF <sub>6</sub> density-monitoring device:	XXXX	
	OEM	XXXX	
	Type	XXXX	
	Temperature range °C	XXXX	
	Density range kg/m <sup>3</sup>	XXXX	
	Accuracy limit at: -10 °C	XXXX	
	+15 °C	XXXX	
	+25 °C	XXXX	
	+35 °C	XXXX	
	+40 °C	XXXX	
	Design principle	XXXX	
<b>2.21</b>	<b>Each main terminal to be an aluminium flat pad of the following dimensions</b>	XXXX	XXXX
	a) Number of holes/pitch mm	8/50	
	b) Diameter mm	14	
<b>3</b>	<b>Insulation and clearances</b>	XXXX	XXXX
<b>3.1</b>	<b>OEM of porcelain/polymer insulators</b>	XXXX	
<b>3.2</b>	<b>Lightning impulse wave (1,2/50 μs) withstand voltage to earth</b> kVpeak	550	
<b>3.3</b>	<b>Power frequency (wet) 60 s withstand voltage to earth</b> kVrms	230	
<b>3.4</b>	<b>Routine power frequency (dry) 60 s withstand voltage</b>	XXXX	XXXX
	a) To earth kVrms	XXXX	
	b) Across open breaks kVrms	XXXX	
<b>3.5</b>	<b>Minimum creepage distances over external insulation</b>	XXXX	XXXX
	a) To earth mm/kV	31	
	b) In parallel with interrupting chambers mm/kV	31	
	c) To earth (90° shadow to axis of insulator – IEC 60815) mm	XXXX	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**64**

OF

**67**

Item	Description		Schedule A	Schedule B
3.6	<b>Preferred phase spacing</b>	mm	1 700	
3.7	<b>Electrical clearances</b>		XXXX	XXXX
	a) Between live portions of phases	mm	XXXX	
	b) Between live portions at system voltage and earth	mm	XXXX	
3.8	<b>Lowest point of insulation above ground level not to be less than</b>	mm	2 500	
3.9	<b>Radio influence voltage at 1 000 Hz</b>	µV	2 500 max.	
4	<b>Miscellaneous</b>		XXXX	XXXX
4.1	<b>Loading on foundations</b>		XXXX	XXXX
	a) Dead mass of three-phase circuit-breaker ready for service	kg	XXXX	
	b) Downwards reaction force to be added to (a) during opening	N	XXXX	XXXX
	closing	N	XXXX	
4.2	<b>Cubicle heating and ventilation</b>		XXXX	XXXX
	Electrical heating		XXXX	XXXX
	a) Supply voltage, 50 Hz	V AC	230	
	b) Power rating	W	Max 400	
4.3	<b>Secondary terminals, gland plate and cable connections</b>		XXXX	XXXX
	a) Terminal type		XXXX	
	b) OEM		XXXX	
	c) Undrilled gland plate of minimum usable area		100x150	
	d) Control cable type used by City Power	mm	PVC SWA	
	e) Minimum distance between terminal board	mm	>150	
4.4	<b>Testing authority certificates held to prove all ratings</b>		XXXX	
4.5	<b>Number of complete sets of instruction manuals and routine test results to be supplied with each circuit breaker</b>		One per circuit-breaker supplied in protective envelope inside mechanism door	

**SPECIFICATION FOR POST-TYPE CIRCUIT  
BREAKER UP TO 132 kV**

REFERENCE

REV

**CP\_TSSPEC\_145**

**0**

PAGE

**65**

OF

**67**

Item	Description	Schedule A	Schedule B
<b>4.6</b>	<b>Number of complete sets of instruction manuals to be supplied on award of contract</b>	10	
<b>4.7</b>	<b>Terminal mechanical loading</b>	XXXX	XXXX
	Maximum continuous loading:	XXXX	XXXX
	Vertical <span style="float: right;">kN</span>	XXXX	
	30° to vertical <span style="float: right;">kN</span>	XXXX	
	60° to vertical <span style="float: right;">kN</span>	XXXX	
<b>4.8</b>	<b>Shunt capacitor-bank switching</b>	XXXX	XXXX
	Maximum "safe" inrush current <span style="float: right;">A</span>	XXXX	
	Maximum inrush frequency <span style="float: right;">Hz</span>	XXXX	
<b>4.9</b>	<b>Shunt-reactor switching</b>	XXXX	XXXX
	Critical arcing time window <span style="float: right;">ms</span>	XXXX	

Tender Number: \_\_\_\_\_

Tenderer's Authorised Signatory: \_\_\_\_\_  
Name in block letters    Signature

Full name of company: \_\_\_\_\_

**Annex C - Technical schedules A and B**

**for**

**88 kV post-type SF6 circuit breakers**

**Deviation schedule**

**Any deviations offered to this specification shall be listed below with reasons for deviation. In addition, evidence shall be provided that the proposed deviation will at least be more cost-effective than that specified by City Power.**

Item	Clause	Proposed deviation

Tender Number: \_\_\_\_\_

Tenderer's Authorised Signatory: \_\_\_\_\_  
Name in block letters Signature

Full name of company: \_\_\_\_\_

---

**Annex D – Stock Items**

The switchgear will be purchased and installed as a turnkey project. It is not intended that City Power should keep stock of these items.