

ELECTRICAL ENGINEERING STANDARDS

STANDARD RWB-EES-002

ELECTRICAL DRAWINGS

Approved: Design Office Manager

Senior Manager Assets

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RECORD OF REVISIONS

Rev – A	Issue for comment approval
Rev – 0	First general issue

1 INTRODUCTION

- 1.1 The objective of this Electrical Engineering Standard is to define an acceptable and uniform standard for the production of Electrical Engineering drawings and documentation.
- 1.2 The standard shall apply for drawings produced within Rand Water and by organisations supplying services and equipment to Rand Water where it is necessary to provide drawings as part of the order/contract. Drawings not complying with Rand Water's standards will be rejected.

2 DEVIATIONS FROM STANDARD

- 2.1 Deviations from this standard will only be permitted at the discretion of the Design Office Manager. Such application for deviation will only be considered if it is made in writing and if accepted such deviation will be granted in writing. Verbal concessions will not be granted.

3 APPLICABLE STANDARDS

- 3.1 The following standard shall apply:

NRS 002:2000	Graphic Symbols for Electrical Drawings
IEC 60617 Parts 2 and 8	Graphical Symbols For Diagrams
SABS 10111:2011 Part 1	Engineering Drawings- General Principles
RW/01200/S/022	Specification for Plant Codification Labels

4 DRAWING PRESENTATION

- 4.1 Standard Drawing Sizes

The following standard drawing sizes are preferred.

Electrical Single Line Diagram	A1 or A2
Electrical Schematic Diagrams	A3
Electrical Wiring Diagrams	A3
Electrical Cable Schedules	A3 or A4
Electrical Connection Schedules	A3 or A4
Electrical Panel General Arrangements	A1, A2 or A3
PLC Hardware Configurations	A2, A3 or A4
Electrical Substation Layouts	A1
Electrical Cable Routing and Racking	A1
Small Power and Lighting Layout Drawings	A1

AO drawings are to be avoided due to the difficulty in physically handling the drawing. If an AO drawing is reduced in size when using Autocad all scales shall be removed and the drawing designated "Not to Scale".

- 4.2 Document Format

The following defines which documents shall be prepared as "drawings" or which are to be prepared as computer generated schedules:

- 4.2.1 Drawings

Electrical Single Line Diagrams
 Electrical Schematic Diagrams
 Electrical Wiring Diagrams
 PLC I/O Schedule
 Electrical Panel General Arrangements

4.2.2 Schedules

Electrical Cable Schedules
Electrical Connection Schedules
PLC I/O Listings (optional as schedule)

Where document is specified as a schedule it shall be prepared as a dBase compatible file with field names and lengths as specified by Rand Water.

4.3 Drawing Sheets

All drawings shall be drawn on Rand Water's drawing sheets. Contractors may add their own logos, title blocks and numbers provided that the main title block is Rand Water's title block. This requirement shall apply for the following drawings:

- Single line diagrams
- Schematic diagrams
- Equipment schedules

Alternatively, contractors may contact the Design Office CADD Team Leader for the latest templates incorporating their logos, etc.

4.4 Drawing Numbers

All drawings shall bear Rand Water's number as the main number. Contractors shall add their drawing number as a secondary number in which case the number shall be clearly identified as the contractor's number. This requirement shall apply for the following drawings:

- Single line diagrams
- Schematic diagrams
- Equipment schedules

The standardised drawing templates included in Annexure A shall be used and will be made available to the Contractor upon award of a contract.

4.5 Title Block Information

Title block information shall convey three basic items of information:

1 st Line	Station name e g Zuikerbosch Pumping Station
2 nd Line	Area name and Discipline e g No 2 Sludge Pump House – Electrical
3 rd Line etc	Drawing type e g 400V MCC Single Line Diagram, Cable Routing Diagram, etc

For schematic diagram drawings the 3rd line shall also include the circuit title e g "Schematic Diagram – Sludge Pump No 23".

4.6 Equipment Numbering – WKS System

All electrical equipment shall be numbered using the Board's WKS equipment numbering system. Provision shall be made on the drawings to incorporate this number as well as the WKS drawing number.

5 DRAWING SYMBOLS AND LETTERING

5.1 Drawing Symbols

All electrical symbols shall be drawn as detailed in the South African National Rationalised Specification NRS 002-2000 Graphical Symbols for Electrical Diagrams.

Symbol sizing shall be according to that specified in the NRS. Electrical symbols shall not be reduced in size to fit into a drawing. Attention shall be paid to the layout to allow for future drawing additions.

Where the NRS 0022000 does not propose a suitable symbol reference shall be made to IEC 60617, or a purpose made symbol may be developed. In such case the symbol selected from IEC 60617, or created, shall be to the approval of the Design Office Manager.

5.2 Lettering Requirements

The following lettering sizes shall be used (dimensions in mm):

Item	AO	A1	A2	A3 & A4
Drawing Number	7	7	7	5
Mark, Item No, View, Section No	5	5	5	3,5
Title – in title block	3,5	3,5	3,5	2,5
Title under detailed item, info on sections	5	3,5	3,5	2,5
Letters and Figures (Body of Drawing)	3,5	3,5	2,5	2,5
Exponents, Small Letters in S1 Units	3,5	2,5	1,8	1,8

5.3 Use of Stencils

Hand drawn drawings using stencils will not be accepted.

All drawings will be drawn in AutoCAD format preferable the AutoCAD 2010 or later.

6 SPECIFIC REQUIREMENTS FOR SINGLE LINE DIAGRAMS

6.1 General Requirements

Where required station main single line diagrams shall be updated to include plant additions as and when they occur.

6.2 Pumping Station Overall Single Line Information Requirements

The plant overall single line diagrams shall not be over simplified for the sake of maximising the amount of information on a single sheet. If necessary the drawing shall be split into more than one sheet in a logical manner so that information is grouped by plant sections on each of the sheets.

For this purpose the single line diagrams shall include the following information:

- Protection scheme details.
- Cable sizes.
- Cable lengths.
- Transformer ratings, ratio, vector group and impedance.
- Large motor details (typically only MV motors for overall single line diagrams).
- Supply authority substation details including transformer size and impedance.

6.3 Drawing Layout

The overall single line drawing shall be laid out with the power flow from top to bottom or left to right. The drawing layout should avoid unnecessary crossing of lines.

6.4 Individual Switchboard Single Line Diagrams

These drawings shall be comprehensive in detail and shall, along with the requirements listed for overall single line diagrams, show all the feeder and motor circuits connected to that board, with the following information:

- a) Rating of all circuit breakers.
- b) Load details including rating and full load current.
- c) Normal running load (calculated) of the incomer circuit(s).
- d) On the incomer circuit the source of the power shall be specified.
- e) Cross reference to the overall single line diagram on which the specific single line diagram appears.

7 SPECIFIC REQUIREMENTS FOR SCHEMATIC DIAGRAMS

7.1 Use of Multiple Drawing Sheets on One Drawing Number

Schematic diagrams for a particular plant item e.g. a motor control centre, MV switchgear panels or similar shall be drawn under one drawing number with multiple sheets.

The set shall include a cover sheet (Sheet 1) and an index sheet (Sheet 2, 3, etc. as required). The index sheet(s) shall list all drawings in the set and shall include the sheet number, drawing title and latest revision for that sheet. Additional sheets shall be included for blank or spare sheets. A materials list as well as cable schedule shall be added to the pack of schematic diagrams and should be right at the end of the pack. The sheets shall be rounded off to nearest five sheets e.g. 15, 20 etc.

7.2 Drawing Information

The information depicted on a single schematic sheet shall be limited to the equipment within a particular panel cubicle. A panel cubicle may extend over more than one sheet but a sheet may not contain more than one panel cubicle's equipment and wiring schematic.

7.3 Grid System

Schematic diagrams shall be drawn on a grid system, columns numbered from 0 to 9 and rows numbered from A to E. Equipment shall be numbered and cross referenced on this grid system.

Appendix A details equipment and wire numbering conventions and standards.

7.4 Schematic Diagram Layout

Schematic diagrams shall be laid out with a minimum spacing of 10 mm between vertical lines. Components shall be laid out evenly in the horizontal plane with the requirement that relay type devices are drawn at the bottom of the sheet.

The power circuit section shall be drawn on the left of the schematic diagram.

7.5 Schematic Diagrams – Medium Voltage Switchgear

Each MV circuit shall have the schematics split over a number of sheeting as follows:

- 1st sheet in sequence ac circuit details including protection and metering.
 - 2nd sheet in sequence closing circuits.
 - 3rd sheet in sequence tripping circuits.
 - 4th sheet in sequence indication and interlocking with external devices.
- The drawings shall cross reference each other.

8 USE OF CIVIL AND/OR MECHANICAL GENERAL ARRANGEMENT DRAWINGS AS A BASE

For cable routing, substation layouts, lighting layouts, etc it is permitted to use sepias of civil, structural, mechanical and architectural drawings as a base. Careful attention shall be paid to the removal of redundant information and as much redundant information shall be removed from the drawing as to minimise and clarify the information content of the drawing. Electrical additions in CAD format shall form one or more separate layers.

Where additions are made to show electrical information and symbols the background shall be removed so that the added information is clearly visible.

9 COMPUTER AIDED DESIGN (CAD) DRAWINGS

9.1 General

All drawings produced shall be AutoCAD based. Hand drawn drawings will not be accepted.

9.2 CAD Software

Rand Water uses Autocad 2018 or newer for its single line and schematic diagrams. Drawings produced by Contractors shall, if not produced using Autocad Ver. 2018, be translated to Autocad Ver. 2018 drawings with a "DWG" file extension. Caddie Ver. 8,9 or 10 or later will be accepted if it saved as a ".DWG" file instead of ".DRW" file extension. Other drawing formats including IGES, Micro-station, E-plan formats, etc. will not be accepted.

9.3 Symbols

Standard symbols shall be installed in a drawing using the "Block" command and shall not be "Exploded". (Retention of blocks is essential to permit regeneration updates if it is necessary to update symbols at any stage.) If it is necessary to produce a new symbol it shall be produced using the "Wblock" command and then entered as a "Block". New blocks shall be kept on the master library as a backup.

Should a contractor so desire, Rand Water, will make its symbol library available. In such case the library will be available as "DWG" extension drawing files. Rand Water, in making such library available does so, as an aid to the contractor but in so doing accepts no responsibility whatsoever for any quality problems, delays, errors, etc that may arise as a result of software and/or hardware incompatibilities that may occur between Rand Water's and the contractor's systems.

9.4 Use of Layers

The use of layers shall be strictly controlled with the following rules being applied:

- Layer 0 Title Block and drawing frame.
- Layer 1 Symbols and interconnecting wires.
- Layer 2 Wire numbering and terminal numbering.
- Layer 3 Notes.
- Layer 4 Revision balloons and triangles (Section 9).

9.5 Wire Numbering Procedure

As detailed in the Appendix wire numbers shall be prefixed with the drawing sheet number. To facilitate automatic and complete revision of the prefix the prefix shall be entered as a Block command wherever it occurs.

9.6 CAD Drawings for Approval

CAD drawings submitted for approval may be paper plots.

9.7 Final Submission of CAD drawings

Final "as built" drawings shall be submitted to Rand Water on CD-R compact disks in Autocad Ver. 2010 or later format. Two CD-R disks of all the drawings shall be provided. Each drawing microfilm holder shall have Rand Water's contract number, contract title, station name, drawing number and drawing title upon it. Microfilms shall comply with the requirements of SABS 0141-1988

Final drawings produced within Rand Water shall be in the form of full size plastic plotted using ink pens. Backup copies of the Autocad files shall be kept in a separate location to the original copy of the files.

9.8 Backup Procedure

Regular backup copies of drawings shall be made of all CAD drawings as they are produced. Two sets of backups shall be created, namely a daily backup and on a separate disk a weekly backup.

10 DRAWING REVISION CONTROL

10.1 Drawing Revision Sequences

Until a drawing has been approved for construction/manufacture its revisions shall be alpha characters A, B, C, etc. Each time a drawing is revised its revision letter shall be increased alphabetically.

Once a drawing has been approved the revision numbering shall be changed to numeric and shall begin with 0 and increasing 1, 2 etc.

The preferred revision numbers are as follows:

- A+ Preliminary Design
- 0 Approved Design Drawings
- 0.A+ Design changes during manufacture
- 1 As built in factory
- 1.A+ Modifications on site
- 2 As commissioned
- 2.A+ Post commissioning modifications

10.2 Revision Identification

All drawing revisions shall be identified by:

- (i) A cloud around the component of the drawing that has changed, been added or space where a deletion has occurred.
- (ii) A triangle with the latest revision character inserted in the triangle situated adjacent to the revision.
- (iii) If it is necessary to completely redraw a drawing it shall not be clouded but the revision block shall bear the words "Drawing Redrawn".
- (iv) When a revision number is increased the references (clouds and triangles) to the previous revision shall be removed.

To facilitate the addition and removal of revisions the clouds and triangles can be added to the rear (for drawings on plastic) and be on a unique layer if the drawing is a CAD drawing.

A brief summary of the revision shall be inserted in the revision block and the revision number shall correspond to the latest triangle revision number.

When a drawing is approved for construction the revision block references to the A, B, C, etc revisions shall be removed and only the numbered sequences shall apply.

11 CROSS REFERENCING OF DRAWINGS

11.1 Reference Block

The electrical drawings shall cross reference correctly.

Detailed cross references to other drawings e g single line diagrams, general arrangements and civil and architectural drawings shall be included.

Detailed cross references to sheet numbers and grid positions shall be included for schematic drawings with multiple sheets.

11.2 Single Line Diagrams

Particular attention shall be applied to single line diagrams for cross referencing with overall plant single line diagrams. Whenever additional plant is added the single line diagrams shall cross reference completely.

12 DRAWING CHECKING AND APPROVAL PROCEDURE

All drawings shall be sequenced through the checking and approval procedure completely.

12.1 General

Drawings shall form part of the design process as stipulated in Section 5 of the FIDIC General Conditions- Design and Build.

12.2 Tender Drawings

Drawings issued with a tender document pack shall be for "tendering purposes" only, to enable the contractor to evaluate the equipment requirements and to price the work required.

12.3 Construction Drawing Preparation

The contractor shall review the tender drawings and prepare drawings for construction in accordance with his/her obligations under Section 5.1 of the FIDIC General Conditions- Design and Build.

Contractors shall liaise with Rand Water Design Office CADD team leader to ensure that all drawings are in the right formats and comply with all the necessary standards and conditions as laid out in this document.

Once drawings have been completed they shall be submitted to Rand Water for review and checked for construction.

12.4 Drawing Review and Checking

No drawing may be issued for approval unless it has been checked and signed off as checked. The checker shall not be the same person as the original designed/draftsperson.

Checking shall follow the following procedure:

12.4.1 The drawing shall be drawn and handed to the checker who shall check all lines, dimensions, cross references, numbering, etc to ensure there are no errors. As each item is checked a yellow line shall be drawn over the item checked. If an alteration is needed it shall be marked in red.

12.4.2 The drawing shall be corrected and the person making the corrections on the drawing shall cross off the change as being completed by means of a blue marker to verify the change has been made. The check print shall be retained by the draftsperson until the drawing is finally taken to "as built" status.

12.4.3 After the drawing has been back drafted the checker shall verify all the corrections have indeed been made correctly. At this stage the drawing may be signed as "checked" and issued for approval.

12.5 Drawing Approval

Once a drawing has been checked it may be issued for approval. A drawing being issued for approval is raised to Revision 0.

Approval shall be as follows:

Electrical Single Line Diagrams	DOM
Electrical Schematic Diagrams	DOM
Electrical Wiring Diagrams	DOM
Electrical Cable Schedules	DOM
Electrical Connection Schedules	DOM
Electrical Panel General Arrangements	DOM
PLC Hardware Configurations	DOM
PLC I/O Listings	DOM
Electrical Cable Routing and Racking	DOM
Substation Layouts	DOM
Lighting Layout Drawings	DOM
Electrical Equipment Lists	DOM
Contractors' Drawings	DOM

No drawing may be issued to a Contractor or used for manufacture unless it is approved. Similarly a Contractor may not be permitted to proceed with manufacture of equipment or installation unless his drawings have been approved by Rand Water.

13 AS BUILT DRAWINGS

13.1 Drawings marked up to "As Built" status

The following drawings shall be raised to "As Built" status at the completion of a project:

Electrical Single Line Diagrams
Electrical Schematic Diagrams
Electrical Wiring Diagrams
Electrical Cable Schedules
Electrical Connection Schedules
Electrical Panel General Arrangements
PLC Hardware Configurations
PLC I/O Listings
Substation Layouts
Lighting Layout Drawings
Electrical Equipment Lists

- 13.2 The drawing revision triangles and clouds shall be all removed.
- 13.3 The revision block shall have all previous revision information removed and the revision level raised one level and the revision "As Built" recovered.
- 13.4 An original paper copy and a film copy of the required size shall be signed as checked and accepted by the Rand Water Design Office Manager or delegated person. The Contractors' professionally registered person shall sign the "As Built" drawing as approved. The full initials, surname, ECSA registration number of the approving person and the date of approval shall appear on the drawing. Final drawings without this information will not be accepted. All AutoCAD drawings shall be supplied on a CD in "DWG" format once the drawings have been approved or is made as built, etc, as it remains the property of Rand Water.

APPENDIX A – SCHEMATIC DIAGRAM COMPONENT AND WIRING NUMBERING SYSTEMS

A1 COMPONENT NUMBERING

All components on schematic diagrams shall be numbered according to Rand Water's WKS numbering systems. The component numbering shall comprise one alpha character prefix followed by three numeric characters as follows:

Alpha Prefix (note the "-" is part of the prefix and shall be included in the designation).

- A Assemblies and sub assemblies.
- B Transducers for non-electrical quantities.
- C Capacitors.
- D Digital elements, time delay equipment, memory equipment.
- E Special unit components.
- F Protection equipment (fuses, auxiliary power circuit breakers, moulded case circuit breakers, miniature circuit breakers, links, etc).
- G Generators, Power Supplies including Uninterruptible Power Supplies and Battery Chargers.
- H Annunciator systems including indicators and lamps.
- J
- K Relays and contactors.
- L Inductances.
- M Electric motors.
- N Amplifiers, controllers.
- P Measuring devices, test equipment.
- Q Power switching devices (air circuit breakers, vacuum circuit breakers and motorised moulded case circuit breakers).
- R Resistors.
- S Switches, selectors and isolators.
- T Transformers (including current and voltage transformers).
- U Modulators, transducers of electrical to electrical quantities.
- V Vacuum tubes and semiconductors.
- W Current transmission systems.
- X Terminals, plugs and sockets.
- Y Electrical actuated equipment.
- Z Cable terminations, compensating equipment, filters, limiters.

Numeric Follower

First two digits will be the drawing sheet number. For Sheets 1 to 9 the number 01 to 09 shall apply and then 10, 11, etc thereafter.

The third digit shall be the column on the drawing grid system in which the component occurs. In the case of relay contacts it shall be the column in which the associated relay coil is drawn.

Alpha Suffix

It may be necessary to add an alpha suffix if more than one component of the same alpha prefix occurs in a grid column. The suffix shall be A, B, C, etc as required (e g -K035A and -035B, etc).

A2 WIRE NUMBERS – GENERAL

All wire numbers shall be shown on the schematic diagram. The numbers shall be applied to a c circuits and on control circuit wiring. Primary power circuits shall not be numbered but shall be phase colour coded. The number shall be four digits long with the number structure being.

1st and 2nd digits – sheet number as above.

3rd and 4th digits shall be sequential numbers allocated in a logical fashion working left to right and top to bottom. The live rail being numbered "LO1" and the neutral rail being numbered "N99".

Where a number leaves a compartment then the number shall be prefixed by the compartment location number as defined by the WKS numbering systems.

A3 WIRING NUMBERING – A C SECONDARY CIRCUITS

The following prefixes shall be applied to a c secondary circuit numbering for voltage and current circuits:

- B Busbar (buszone) protection current circuits.
- C Protection current circuits.
- D Metering current circuits.
- E Voltage/potential circuits.

A4 WIRE NUMBERING – D C CIRCUITS

- J 110V d c supplies

The numbering of the wires shall be as follows:

- | | | |
|--|---|--------------------------------------|
| 1 st and 2 nd digits | - | the schematic sheet number as above. |
| 3 rd and 4 th digits | - | as follows: |
| Red phase | - | numbered 10 to 29. |
| White phase | - | numbered 30 to 49. |
| Blue phase | - | numbered 50 to 69. |
| Neutral | - | numbered 70 to 89. |
| Earth | - | Numbered 99. |

Wires leaving a compartment shall be further prefixed by the compartment number according to the WKS numbering system.