ISBN 978-0-626-22830-9

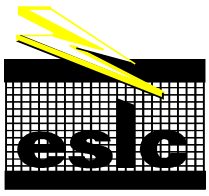
NRS 048-6:2009

Edition 1

ELECTRICITY SUPPLY — QUALITY OF SUPPLY

Part 6: Measurement and reporting of medium-voltage network interruption performance

This document is not a South African National Standard



This specification is issued by
the Standardization Section, Eskom,
on behalf of the
User Group given in the foreword.

Table of changes

Change No.	Date	Text affected

Correspondence to be directed to

The NRS Projects Manager
The Standardization Section
Industry Association Resource Centre
Eskom
Private Bag X13
Halfway House 1685

Telephone : (011) 651 6842
Fax : (011) 651 6827
E-mail : nrs@eskom.co.za

Website : http://www.nrs.eskom.co.za

Printed copies obtainable from

SABS Standards Division
Private Bag X191
Pretoria 0001

Telephone : (012) 428-7911
Fax : (012) 344-1568
E-mail : sales@sabs.co.za

Website : http://www.sabs.co.za

Printed in the Republic of South Africa
by the SABS Standards Division
1 Dr Lategan Road, Groenkloof, Pretoria

Foreword

This part of NRS 048 provides a framework for the measurement principles, key performance measure definitions, high-level event data quality assurance, data accuracy auditing requirements, and the requirements for medium-voltage network interruption performance reporting in the South African Electricity Distribution Industry (EDI). This part of NRS 048 addresses the impact on MV and LV customers' supply interruptions caused by events on the medium-voltage (MV), high-voltage (HV) and extra high voltage (EHV) systems.

This part of NRS 048 also provides the minimum requirements for an interruption performance management system for either the manual or automatic capturing and recording of interruption event data. The high-level interruption cause codes are provided as a minimum requirement for associating the supply interruptions with a common cause code hierarchy. The relevant requirements for the disaggregation reporting, as well as the annual regulatory reporting, benchmarking reporting and incentive-based reporting are provided.

It is recognized that present systems of the distribution licensees do not comply with the minimum requirements specified in this part of NRS 048 and therefore that the implementation of this part of NRS 048 will require resources, time and additional work by the distribution licensees. It is anticipated that the National Energy Regulator of South Africa (NERSA) will specify the time frame and compliance level for such implementation, in consultation with the various Distribution Industry stakeholders. A distribution licensee may require full exemption or selective exemption from the implementation of this part of NRS 048 from NERSA. This request for an exemption also applies to licensees whose purpose is not only distributing electricity. In particular, some requirements in terms of reporting integrity need to be considered as "end-state" requirements (as once a system has been fully implemented); it may take some time to reach these levels of reporting completeness and accuracy. Requests to NERSA for exemptions from implementation should be accompanied by an implementation plan that states when the licensee aims to comply.

The first edition of this part of NRS 048 was compiled by representatives of the South African Electricity Distribution Industry (EDI) in a working group appointed by the Electricity Suppliers Liaison Committee (ESLC). The working group membership included the Government Department of Public Enterprises (DPE), the Distribution Industry, NERSA, Eskom Holdings and end customers. In compiling this part of NRS 048, the working group was guided by key international developments such as the IEEE 1366 standard, *Guide for electric power distribution reliability indices,* the work and irecommendations of the international IEEE Task Force on Reporting Practises, the recommendations of Cigré Technical Report TB261, *Power quality indices and objectives,* the United Kingdom (UK) regulatory standard of the Office of Gas and Electricity Markets (ofgem), *Quality of service regulatory instructions and guidance,* and the experiences and lessons learnt by the Eskom Distribution Division and the AMEU members.

The regulatory requirements of the NERSA and the business and operational needs of the distribution licensees were taken into account in the preparation of this part of NRS 048, to provide uniform and robust measurement and reporting procedures in respect of network interruption performance. In particular, the anticipated implementation of Incentive Based Regulation (IBR) will require accurate and consistent reporting methods and accurate and complete data collection, to facilitate appropriate target setting. The document will also assist all the distribution licensees in their correct interpretation and application of the network interruption performance reporting requirements of distribution networks to the NERSA. It will also support the future development of indicative network interruption performance levels for various network categories or even customer categories.

Foreword *(concluded)*

This part of NRS 048 was compiled by a working group on behalf of the Electricity Suppliers Liaison Committee (ESLC). At the time of publication the working group, which was appointed by the ESLC, comprised the following members:

AJ Dold (Chairman)	eThekwini Electricity
SA Adams	Nelson Mandela Metropolitan Municipality
DK Bhana	Eskom Holdings Ltd (KSACS Division)
BG Chatterton	Eskom Holdings Limited (Distribution Division)
S Delport	Ekurhuleni Metropolitan Municipality
G de Beer	Sasol
HJ Geldenhuys (Dr)	Eskom Holdings Limited (Corporate Service Division)
PA Johnson (Project Leader)	Eskom Holdings Ltd (Corporate Services Division)
AC Kachelhoffer	Tshwane Electricity
I Kekana	Tshwane Electricity
RG Koch	Eskom Holdings Limited (System Operations and Planning Division)
M Kneen	Glass Manufacturing Industry
J Maree	Mondi Paper
R McCurrach	Eskom Holdings Limited (Transmission Division)
H Mostert	Eskom Holdings Limited (Distribution Division)
ME Motaung	NERSA
V Shikoana	Eskom Holdings Limited (Distribution Division)
I Sigwebela	Eskom Holdings Limited (Transmission Division)
P van Niekerk	Energy Intensive User Group (EIUG)

NRS 048 consists of the following parts, under the general title *Electricity supply – Quality of supply:*

Part 2: Voltage characteristics, compatibility levels, limits and assessment methods.

Part 4: Application guidelines for licensees.

Part 6: Measurement and reporting of medium-voltage network interruption performance.

Part 8: Measurement and reporting of extra high voltage (EHV) and high voltage (HV) network interruption performance.

Part 9: Load reduction practices, system restoration practices and critical and essential load requirements under system emergencies. (In course of preparation.)

Annexes A, B and C are for information only.

Introduction

In order to measure, assess and audit the reliability and availability of electricity supplied by distribution licensees, the NERSA will require licensees to have uniform and robust measurement and reporting procedures in respect of medium-voltage network interruption performance. This will be important to reduce regulatory uncertainty and provide confidence in the interruption of supply related indices supplied by the distribution licensees of South Africa. In terms of the requirements and principles of economical and affordable electricity supply in South Africa, it is essential to achieve a fair balance between the cost and the adequacy of the measurement and reporting requirements. This includes the associated computer, database and supervisory control and data acquisition (SCADA) systems that may be implemented to achieve the requirements.

There is also a long-term strategic benefit in that this part of NRS 048 will greatly assist the distribution licensees with the NERSA implementation of Incentive Based Regulation (IBR) and the national annual reporting of network interruption performance indices. The end objective is to cost-effectively improve the reliability and availability of supply to the customers in South Africa.

The NERSA needs to compare "apples with apples" for accurate and reliable interruption performance reporting and possible benchmarking between the distribution licensees in South Africa and potentially with international distribution licensees. This part of NRS 048 will also, in the long term, assist in determining which best work practices and processes the distribution licensees should implement to improve their interruption performance to acceptable levels.

Caution needs to be exercized when network interruption performance benchmark exercises are being conducted. Interruption performance benchmarking requires careful consideration of not only the physical conditions related to the peer group members (e.g. network type and topography, environment, geography, network operating practises and human resource related elements), but also of the measurement, data collection and storage and reporting methods used. Through specifying the latter (taking international practices and key developments into consideration), this part of NRS 048 aims at providing an improved basis in South Africa, for undertaking such internal and international benchmarking activities into the future. However, it is cautioned that any benchmark needs to carefully compare the reporting methods in this part of NRS 048 with the requirements of specifications used by other members of the peer group.

Keywords

network interruption performance, reliability and availability of supply, interruption cause codes, network interruption performance benchmarking, annual regulatory reporting, incentive based regulation, IBR.

This page intentionally left blank

Contents

Contents *(concluded)*

ELECTRICITY SUPPLY — QUALITY OF SUPPLY

Part 6: Measurement and reporting of medium-voltage network interruption performance

1 Scope

1.1 This part of NRS 048 addresses the impact on medium voltage (MV) and low voltage (LV) customers' supply interruptions, caused by events on the medium voltage (MV), high voltage (HV) and extra high voltage (EHV) systems.

This part of NRS 048 provides indices for defining system interruption performance (frequency and duration) on

a) customer interruptions, and

b) installed power transformer capacity.

1.2 This part of NRS 048 provides requirements for reporting the impact on customers of the distribution licensee on three different levels of performance, i.e.

a) the licensee's MV system performance,

b) the licensee's HV and EHV system performance, and

c) the supply intake (e.g. from the national transmission grid and the integrated power system as a whole). Although the LV customers interrupted are reported, the interruptions on LV systems are not included (only the interruptions up to the LV side of the MV/LV power transformer are included). The reporting allows licensees to report only on the performance of the networks under their control and separately report on the total performance impact on all their MV and LV customers.

NOTE 1 HV and EHV system interruption performance indices and reporting are addressed in NRS 048-8.

NOTE 2 The reporting of MV and LV interruption performance is specifically separated from that of HV and EHV interruption performance reporting (as in NRS 048-8), because customer interruption indices (e.g. SAIFI and SAIDI) consider each customer equally; customers are counted as single customers irrespective of their size (i.e. a 100 MVA customer and a domestic customer are counted the same).

1.3 This part of NRS 048 is predominantly focused on the primary plant performance but the key secondary plant-related matters that impact on the primary plant performance are also considered and specified.

1.4 This part of NRS 048 provides a basis for the internal interruption performance management purposes of the distribution licensees. The network events are defined in terms of their duration. The duration is heavily influenced by the internal and external processes of the distribution licensees, and this part of NRS 048 will ensure standard reporting processes amongst all the licensees. High-level internal quality assurance processes, data completeness auditing guidelines

and data accuracy measures are presented to prevent distribution licensees from artificially adjusting their performance statistics due to external regulatory pressures and internal business target setting and financial incentives.

1.5 The key aspects addressed in this part of NRS 048 are

a) medium-voltage interruption performance measurement and data collection requirements,

b) performance indices for reporting and the calculation method of these indices,

c) segmentation according to voltage group (low, medium and high),

d) segmentation of network and a basis for future segmentation of customer types for reporting purposes,

e) treatment and reporting requirements of major events,

f) handling of exclusions and inclusions of events for the various reporting requirements,

g) data collection of interruption cause codes according to a standard hierarchy,

h) requirements for the disaggregation for annual regulatory, benchmarking and incentive-based regulation reporting,

i) data management and archiving, and system-related changes, and

j) estimating the accuracy of reporting through event data audits.

1.6 This part of NRS 048 deals with the norm and does not apply to premium power quality contracts with large customers. The required network interruption performance levels and associated costs to achieve these levels will be negotiated directly with the customer through specific supply agreements.

NOTE 1 See NRS 048-8 for the measurement and reporting requirements of HV and EHV networks.

NOTE 2 In some cases the network voltages of 33 kV could be considered as HV in terms of their design criteria and application by the distribution licensee. The distribution licensee should consult with NERSA regarding the appropriate classification of its voltage networks (MV or HV) for annual regulatory reporting purposes.

1.7 An overarching principle of this part of NRS 048 for good measurement practices by the distribution licensees, is that all supply interruptions (momentary and sustained interruptions) experienced by individual customers, need to be captured (manual or automatic) and recorded in the relevant database of the licensee. This may not be practically and financially possible currently and is a long-term objective (required end state) for the effective management of network interruption performance. In the interim, temporary work-arounds such as inferring the supply interruptions onto a MV/LV transformer and estimation of the number of customers affected may have to be utilized by some licensees. These temporary work-arounds need to be clearly communicated to NERSA.

1.8 The medium-voltage network interruption performance measure reporting methodology will depend on the requirements specified in this part of NRS 048. The calculation and reporting process is recommended to have clearly defined responsible and accountable persons, an auditing process and completeness and accuracy procedures.

NOTE The network interruption performance indices used for regulatory purposes (such as incentive-based regulation) might change from time to time. This part of NRS 048 therefore provides for a range of indices that can be used for regulatory reporting and internal performance management by the distributor licensees.

Performance indices that define worst-served customers are also provided to ensure that the performance levels of individual customers are monitored and reported and the required corrective actions are implemented, where necessary.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies. Information on currently valid national and international standards can be obtained from the SABS Standards Division.

NRS 000-1, *NRS definitions – Part 1: Compilation of NRS and other definitions used in the Electricity Supply Industry.*

NRS 047-1, *Electricity supply – Quality of service – Part 1: Minimum standards.*

NRS 048-2, *Electricity supply – Quality of supply – Part 2: Voltage characteristics, compatibility levels, limits and assessment methods.*

SANS 61000-4-30/IEC 61000-4-30, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods.*

3 Terms, definitions and abbreviations

For the purposes of document, the terms, definitions and abbreviations given in NRS 000-1 and NRS 047-1 apply and should be consulted. Some selected terms are repeated in order to promote better understanding and the correct application of this document.

3.1 Terms and definitions

after diversity maximum demand
ADMD
simultaneous maximum demand of a group of consumers divided by the number of consumers

NOTE 1 ADMD is expressed in kilovolt amperes

NOTE 2 Characteristic ADMD: the value of the ADMD in a specific area of supply generally decreases to an approximate constant value for 1 000 consumers or more. This value is known as the characteristic ADMD. Where the ADMD is used with no mention of the number of consumers, it is assumed to be the characteristic ADMD, and is equal to the design ADMD.

alarm
network or equipment indication warning received for primary or secondary plant in an abnormal state

NOTE 1 This may be due to a possible network fault or a warning indication of faulty equipment.

NOTE 2 Typical examples of alarms are breaker alarms, transformer alarms and AC/DC alarms.

auto-reclose operation
ARC
operation when the network breaker opens its contacts for a set period of time allowing the fault current on the line to be removed and then closes the contacts, restoring voltage supply to the line

NOTE This definition is specific to this part of NRS 048 for momentary interruption reporting.

audit
process of inspecting the procedures, facilities and other relevant items to confirm compliance with requirements

circuit
arrangement of conductors for the purpose of carrying electrical energy

NOTE It is practical to provide a relevant name from “A” to “B” infrastructure to identify different circuits and the points where the circuit starts and ends.

customer
person or legal entity who has an electricity supply agreement with the relevant distribution licensee

NOTE 1 This also includes temporarily disconnected customers but excludes illegally connected customers.

NOTE 2 For the purposes of network interruption performance calculations, the individual customer count can be taken as the number of points of supply or premise. The customer count methodology should be clearly indicated, consistently applied and provided by the distribution licensee to NERSA during the annual reporting process.

customer network link
CNL
index that evaluates the completeness of the data used in the data connectivity model to determine the total number of customers physically connected to the correct transformers

NOTE 1 CNL is expressed as a percentage (%) of the total number of customers connected to the network.

NOTE 2 A CNL of 95 % would indicate that 95 % of the physically connected customers in the network are included in the customer database and their associated interruptions are counted as part of the network interruption performance index calculations.

NOTE 3 A customer who is disconnected for not paying or for tampering with his/her meter will not be counted in an interruption.

NOTE 4 It is the responsibility of the distribution licensee to ensure the accuracy of the CNL at all times. A high percentage CNL does not necessarily imply an accurate CNL. Future revisions of this part of NRS 048 will address methods to report the CNL accuracy and the specific accuracy level requirements per voltage group.

data connectivity model
complete and accurate model of the number of customers connected to a transformer affected by an interruption

NOTE The process of connectivity refers to the ability of the system to infer the interruptions onto all the affected customers (even those customers who did not call in) from the HV system to LV customers connected to MV/LV transformers, from data related to the received calls or the location of the affected device on the network.

distribution licensee
licensee
company that has a licence in terms of the distribution of electricity

NOTE The terms “licensee” and “distribution licensee” are used interchangeably in this document.

emergency
condition that poses an immediate and direct threat to life or could possibly cause severe damage to the plant of the distribution licensee or the customer

NOTE These associated interruptions are dealt with immediately by the distribution licensee and are recorded under the emergency subcategory of the fault category. This definition is specific to this part of NRS 048 for reporting of network interruption performance.

extra high voltage
EHV
set of nominal voltage levels that are used in power systems for bulk transmission of electricity in the range 220 kV < U_n ≤ 400 kV
[NRS 048-2]

frequency
frequency of alternating voltage generated by power system generators

NOTE In South Africa a standard frequency of 50 Hz is used.

high voltage
HV
set of nominal voltage levels that are used in power systems for bulk transmission of electricity in the range 44 kV ≤ U_n ≤ 220 kV
[NRS 048-2]

interruption
event that occurs when one or more phases of a supply to a single customer or group of customers are disconnected for a period exceeding three seconds
[NRS 048-2]

NOTE An interruption is not defined in terms of voltage measurement, but rather in terms of the disconnection of the supply point. The interruption can be a sustained interruption or a momentary interruption of supply. A network event of duration three seconds or less and with partial or full voltage loss, is classified as a "voltage dip" (see NRS 048-2).

interruption on MV and LV networks

a) **momentary interruption**

interruption of supply in the **range > 3 s to ≤ 5 min**

NOTE 1 Where an interrupting device has a sequence of operations, for example if a recloser or breaker operates multiple times and then holds because of an event, those momentary interruptions are counted as separate momentary interruptions. The individual momentary interruptions are part of the MAIFI calculation and the momentary interruption event (that comprises two to four subsequent operations) forms part of the MAIFIe calculations.

NOTE 2 The number of customers affected by momentary interruptions should be identified in the same way as for sustained interruptions.

b) **pre-arranged planned interruption**
planned and co-ordinated interruption of supply to the customer which involves a number of successive switching operations that are all treated as a single interruption

c) **re-interruption**
subsequent sustained unplanned interruption (see definition of "unplanned interruption") to customers during the step restoration of supply process, or fault finding, or network operating and switching, to those same customers that had experienced a previous sustained interruption

NOTE Subsequent interruptions are only classified as re-interruptions if the cause of the subsequent interruption was at the **same physical location** on the network as the original interruption and **occurred less than three hours** after the original interruption. If these criteria are not met, the subsequent I nterruption is counted as a new interruption and assessed separately.

d) **sustained interruption**
interruption of supply with a duration **> 5 min**

e) **unplanned interruption**
interruption of supply due to network transient or permanent conditions, protection maloperation, or switching error by the distribution licensee

NOTE These interruptions exclude those caused by load reduction related events.

licensee
body, licensed by the National Energy Regulator of South Africa, that generates, transmits or distributes electricity

live work
work conducted on a section of network or plant during energized conditions where the supply to the customer was not lost using standard accepted maintenance techniques

load shedding
action taken by the licensee direct, or as a result of instructions from the system operator, to cause load reduction through switching off or restricting the supply to the customer

NOTE Load shedding can be initiated through manual intervention or automatically, and might be in response to national capacity constraints or to avoid overloading of a portion of a licensee's network

losses
supply losses
energy not supplied as a result of the network interruption of supply

NOTE Losses are measured in MVA hours. The figure for MVA is based on the installed transformer MVA rating or the transformer name plate rating and the hours figure is based on the duration of the network interruption.

low voltage
LV
set of nominal voltage levels that are used for the distribution of electricity and whose upper limit is generally accepted to be an a.c. voltage of 1 000 V (or a d.c. voltage of 1 500 V)
[SANS 1019]

major event
extraordinary event that exceeds the reasonable design (best engineering design methodologies), or the expected normal operational limits of the electrical networks of the distribution licensee

NOTE These events can also be due to very large scale natural events affecting a large customer base or many networks. See the *"force majeure"* definition in NRS 048-2. The criteria for major event reporting are covered in 5.3.3.

medium voltage
MV
set of nominal voltage levels that lie above low voltage and below high voltage in the range **1 kV ≤ U_n < 44 kV**
[NRS 048-2]

network
electrical infrastructure over which energy is transported from a source to a point of consumption and comprises a combination of different circuits

network event
occurrence or series of events on the network of the distribution licensee, or any other nearby connected distribution licensee, or transmission and generation licensee, that results in either a single or series of sustained or momentary interruptions of supply to the customer

network interruption performance
level of reliability (frequency of momentary and sustained interruptions) and availability (duration of momentary and sustained interruptions) of supply received by the end customer connected to a distribution licensee's network

pareto analysis
80-20 principle
engineering rule-of-thumb analysis technique that identifies the 20 % of phenomena that result in 80 % of consequences

NOTE The subsequent selection of the most effective actions based on the identified 20 % that deliver the total benefit is reasonably close to the maximal possible one.

permission to operate
PTO
permission to switch
PTS
process whereby the network control centre of the distribution licensee temporarily hands over the network control responsibility to the field staff

NOTE This process allows the field staff to operate and switch the network without the supervision of the control centre. All operating is recorded real time or is manually recorded in the operating log sheet and afterwards manually captured into the interruption management system or database.

reporting period
period for reporting the network interruption

NOTE The performance indices are by default assumed to be a calendar year (January to December) window.

step restoration
process of restoring supply to individual customers or re-energizing an interrupted network in stages over a period of time

NOTE The restoration of supply to the customers will be conducted in phases and eventually all the affected customers will have supply restored.

third party
external person or company that is not part of the customer, or contracted by the customer or by the distribution licensee

NOTE This excludes the generation licensee, transmission licensee or adjacent distribution licensee.

total number of customers served
number of customers connected (including the disconnected customers) to the network

NOTE This number is used as a denominator in the network interruption performance index calculations and needs to be as accurate as possible.

3.2 Abbreviations

ADMD: after diversity maximum demand

ARC: auto-reclose

ASAI: average service availability index

CAIDI: customer average interruption duration index

CAIFI: system average interruption frequency index

CNL: customer network link

DPE: Department of Public Enterprises

IBR: Incentive Based Regulation

IEEE: Institute of Electrical and Electronic Engineers

MAIFI: momentary average interruption frequency index

MSLI: MVA supply loss index

NERSA: National Energy Regulator of South Africa

PTO: permission to operate

PTS: permission to switch

QoS: Quality of Supply

RTU: Remote Terminal Unit

SAIDI: system average interruption duration index

SAIFI: system average interruption frequency index

SCADA: Supervisory Control and Data Acquisition

WAIFI: momentary average interruption frequency index of events

4 Minimum requirements for network interruption performance reporting

NOTE NRS 048-4 provides additional guidance for system requirements that may further enhance the interruption performance reporting and interpretation of the measured statistical trends.

4.1 Capturing of network events

A distribution licensee may choose to implement automatic (system) or manual recording of events. The procedures (and where appropriate, system functionality) for capturing of network events shall

a) allow for facilitation of the structured capture of all interruption of supply events (including telemetered and non-telemetered events that occur on the networks),

b) allow for capturing the correct individual customer restoration of supply times during fault finding and network switching. This shall allow for the manual entering of all switching or operating actions during the customer supply restoration process,

c) allow for the interruption cause-code hierarchy capturing in accordance with the requirements given in clause 8,

d) allow for an accurate and complete customer connectivity model from the HV system to the LV customers connected to the MV/LV transformers. The customer connectivity model shall be maintained and updated regularly by the distribution licensee. The connectivity model shall have minimum data accuracy and completeness levels (see NOTES 1 and 2) of

1) in the case of HV customers : > 99 % of all HV customers accurately linked,

2) in the case of MV customers : > 95 % of all MV customers accurately linked, and

3) in the case of LV customers connected to MV/LV transformers:> 75 % of all LV customers accurately linked,

e) allow for the location of network faults based on events and information received through SCADA, customer calls logged at the call-in centre, and signals received from protection devices on the network (see NOTE 3),

f) allow for the captured event data to be merged and filtered into logical formats or formats specified by the distribution licensee,

g) provide diagnostic procedures to be implemented to identify the missing or incorrect plant location data, and

h) ensure that procedures are in place to allow for automatic or manual linking of interruption of supply events to specific locations on the network.

NOTE 1 The percentages in 4.1 (d) (1), (2) and (3) are based on the end state. It is recognized that licensees might not be at the current completeness levels and will require time to reach the required levels of completeness.

NOTE 2 Distribution licensees might need to justify to NERSA, levels less than the above recommended levels based on their particular operating environment, business circumstances and resource constraints.

NOTE 3 It is recognized that not all distribution licensees will have full SCADA coverage.

4.2 Data correction and manual editing

The procedures (and where appropriate, system functionality) for data correction and manual editing shall allow for the following:

a) manual event data correction or for the missing data to be captured afterwards (post event);

b) the review of the switching or network operation steps in chronological order, the individual customer on and off times and the affected customer counts;

c) the addition of a new switching step, the deletion of an existing switching step and the edition of existing switching steps;

d) the downstream customer information to be re-calculated and the overall network interruption performance indices to be adjusted accordingly; and

e) an audit trail to track the persons responsible for changing the data.

4.3 Network event and statistical reporting

4.3.1 The reporting functionality shall allow for the following:

a) geographical reporting hierarchy (total system, district or area, substation and per network);

b) reporting per voltage level and pre-determined voltage groups;

c) reporting per interruption type category (see 5.1); and

d) reporting the network interruption performance indices monthly (actual), yearly (every 12 months) and in a year to date (YTD) window.

4.3.2 The following network event information shall be reported on:

a) the date and start and end times of the network event;

b) the name of the network affected;

c) the number of individual interruptions that occur;

d) the number of customers affected;

e) the number of large or major customers affected (including downstream);

f) customer hours lost; and

g) transformer kVA affected.

4.3.3 The following statistical information shall be reported on:

a) the number of interruptions per customer interrupted;

b) the total number of hours per interruption;

c) the frequency and duration of events per cause-code category (e.g pareto analysis);

d) individual customer interruptions can be created at each load point through user selection of the customer from a list of all connected customers;

e) the total circuit length per network (MV underground and overhead);

f) live work reports (optional functionality to report on the interruptions “saved’ due to the planned interruptions being performed through live work techniques);

g) the breakdown reports for the interruption categories;

h) the number of momentary interruptions;

i) the number of sustained interruptions;

j) the network category in accordance with the definitions in NRS 048-2.

4.3.4 The following types of customer category description and relevant information shall be reported on (the type of customer affected by the interruptions):

a) residential customers (large): customers that use electricity at their place of residence and typically have an ADMD > 1. This includes customers that work from home;

b) residential customers (small): customers that use electricity at their place of residence and typically have an ADMD ≤ 1. This type if customer is normally funded from the National Electrification Fund or from similar government grants and cross subsidies;

c) agricultral customers: customers that use electricity for the purpose of economic activity related to agriculture (i.e. farming; mostly include supply to households. This would include farming in an urban or sub-urban environment.);

d) industrial customers: customers that use electricity for the purpose of industrial production, mostly situated in declared industrial areas. This category includes mining-related customers;

e) commercial customers: customers that use electricity for the purpose of trading activities. They are normally situated in declared commercial areas (including tourism, retail, banking and education customers).

For further clarity, annex A links the standard industrial classification (SIC) codes for customer categories to the above categories.

NOTE 1 The customer category descriptions are intentionally broad to accommodate the majority of customer types in South Africa. Distribution licensees may use more exact definitions to better suit their business, as long as they align with the broad customer descriptions above. This is to ensure uniform and consistent customer interruption reporting in South Africa.

NOTE 2 The interruption performance levels per customer category are a long-term regulatory reporting requirement as part of an effective and value-adding incentivized regulation approach. The customer database of the distribution licensees will need the customer category identified and recorded for reporting.

5 Interruption categories for reporting

5.1 General

In order to facilitate the various reporting requirements, categories and associated subcategories of sustained and momentary interruptions are defined below. An interruption is not defined in terms of voltage measurement, but is rather defined in terms of the disconnection of the supply point. Voltage measuring instruments may in some cases provide erroneous messages on whether an interruption occurred or not. Instruments specified in accordance with SANS 61000-4-30 may be used to assist in the interruption assessment.

NOTE 1 When interruption performance data are being provided, the exclusion of any categories of interruption shall be clearly specified by the distribution licensees with the submission to NERSA. It is anticipated that NERSA will clearly define which categories need to be included or excluded in the reporting requirements.

NOTE 2 The quality of service-related measures (such as the number of planned interruptions that start and end on time and the effective customer communication about pending planned interruptions) are not in the scope of this part of NRS 048, as these form part of the scope of NRS 047. This part of NRS 048 only covers the technical performance measures experienced by the customers.

5.2 Interruption categories

5.2.1 Categories and codes

The categories and subcategories for the classification of interruption types are listed in 5.2.2.to 5.2.5 (the definitions and application of the various categories are defined in 5.3 to 5.6). Category codes are defined in order to encourage consistent and common data reporting by distribution licensees.

5.2.2 Unplanned interruption (“U”)

The following apply:

a) network event [“UN”];

b) emergency [“UE”];

c) major event [“UM”]; and

d) third party [“UT”].

5.2.3 Planned work (“P”)

The following apply:

a) pre-arranged [“PA”]; and

b) major event [“PM”].

5.2.4 Customer related (“C”)

The following apply:

a) customer caused [“CC”]; and

b) customer requested [“CR”]

5.2.5 Intake supply related (“S”)

The following apply:

a) unplanned [“SU”];

b) planned [“SP”]; and

c) load shedding [“SL”].

NOTE 1 The supply-related category also includes the unplanned interruptions caused by or the planned interruptions requested by distributed generation.

NOTE 2 The load shedding related interruptions are reported separately as these interruptions are not related to normal network interruption performance.

5.3 Application of unplanned interruption category

5.3.1 Network event

An unplanned interruption shall be categorized as a “network event” where any one of the following applies:

a) the interruption is due to network fault conditions (transient or permanent), or to protection maloperation, or to switching errors made by the staff of the licensee;

b) the affected customers did not receive any formal notification of the pending planned interruption; and

c) insufficient notification time (as defined by NRS 047-1 or in the relevant customer contract) was provided to the customer.

NOTE Currently NRS 047-1 specifies a 48 h notification time for planned interruptions to customers.

5.3.2 Emergency

An unplanned interruption shall be categorized as an “emergency” where it can specifically be shown that a condition existed that posed an immediate and direct threat to life, or could possibly have caused severe damage to the plant of the distribution licensee or to the customer. These unplanned interruptions are conducted by the licensee with minimal or no notification to the customer.

5.3.3 Major events

5.3.3.1 Introduction

A major event is considered to occur when there are conditions or events on the network that result in many customers being affected, or a significant amount of installed transformer MVA is lost (installed transformer rating), or where conditions or events result in supply restoration times longer than times expected under normal operating conditions. This may also relate to abnormal network events where the licensee was not staffed sufficiently enough to effectively manage and respond during a crisis situation.

The major events for MV networks as defined in this clause, shall be assessed separately from the network interruption performance indices and reported separately by the distribution licensee. The intention is to report the actual underlying performance level (normal operational performance) that is not distorted by valid abnormal situations or one-off exceptional events that occur and that are out of the distribution licensee's control (crisis mode operation). The distribution licensee shall proactively manage both the normal operational performance and crisis mode operational performance, to ensure that appropriate overall levels of reliability and availability of supply are provided to the end customers.

The normal operational performance and crisis mode operational performance segmentation will assist the licensee as a basis for the review of its operational effectiveness, emergency organization arrangements and response, work practices and network management, and also assist NERSA in appropriate target setting in a future IBR environment.

NOTE Any load shedding required due to a shortfall in generation in one form or another, by the transmission licensee to the distribution licensee, is an "intake supply related event" and ought to be assessed and reported separately. The major event categories relate only to events directly attributed to the distribution licensee. It is not necessary to include intake supply related load shedding events under major events unless the distribution licensee itself had to shed load due to a capacity restraint and then only if it fits the criterion specified below; otherwise it would be treated as an unplanned interruption.

5.3.3.2 Major event criterion A: licensee performance comparison (for annual regulatory reporting and distribution licensee comparison on a national basis by NERSA)

An unplanned interruption shall be categorized as a "major event" for distribution licensee comparison reporting purposes, where any one of the following conditions is met:

a) a loss of more than 300 000 customer hours is incurred as a result of a single event (where the number of customer hours is the product of the number of customers interrupted and the sum of their interruption durations); or

b) a loss of more than 300 transformer MVA capacity hours is incurred as a result of a single event (where the "transformer MVA capacity hours" is the sum of the MVA capacity of MV/MV and MV/LV transformers serving the customers that have been interrupted).

NOTE The major event criterion A uses a fixed quantum that will allow for equitable and consistent comparison of small and large distribution licensees in South Africa. Some of the larger distribution licensees may report many major events according to criterion A, due to the large customer base or large installed MVA. Some of the smaller distribution licensees may report a few numbers of major events. The intention is to normalize the larger events for large and small distributions and provide a consistent national picture of the performance trends. The actual quantum may be revised in future revisions of this part of NRS 048 once historical data is collected and a better understanding of the reported figures is available.

5.3.3.3 Major event criterion B: one-off non-weather abnormal events (for annual reporting and year on year licensee performance tracking)

An unplanned interruption shall be categorized as a “major event” for one-off non-weather abnormal event reporting where any one of the following conditions are met:

a) more than 10 % of the installed customer base of the distribution licensee is without supply and the affected customers have been without supply for 12 h or longer;

b) more than 10 % installed MVA transformer base of the distribution licensee is without supply and the affected transformers have been without supply for 12 h or longer; or

c) through a specific agreement in writing between the relevant distribution licensee and the NERSA and that has been published on the NERSA website in the public domain.

The licensee’s actions or lack of actions shall not be direct contributory factors to the occurrence of the major event and the licensee shall take all appropriate steps within its power to restore the supply to the affected customers or transformers.

NOTE 1 These widespread supply interruptions are due to non-severe storm-related rare events that were not reasonably predictable and where it was reasonably not possible to mitigate their impact of the events on the network.

NOTE 2 The major events criteria will allow for the aggregation of South African statistics and assist in determining the underlying performance (normal operational mode) and major event performance (crisis mode operation) trends for regulation purposes.

NOTE 3 The major event criteria should be applied in the case of the formal areas of distribution of each distribution licensee. For example, in Eskom distribution, the major event criteria will be applicable to the individual regions.

5.3.3.4 Major event criterion C: severe weather events (for annual reporting and year on year licensee performance tracking)

An unplanned interruption shall be categorized as a “major event” for severe weather event reporting where the following conditions are met:

a) a minimum of 5 % of the customer base is affected and valid severe weather-related events that were reported by the weather service of South Africa occurred;

b) through a specific agreement in writing between the relevant distribution licensee and the NERSA and that has been published on the NERSA website in the public domain occurred

NOTE 1 Severe weather events are categorized by being long-duration events and by the large number of customer interruptions that occur during the restoration of supply. The above criterion is cumulative and may in exceptional circumstances occur over several days. The impact of severe weather is also on the surrounding environment that may indirectly add to the impact on the network and customers.

NOTE 2 The severe weather events does not cover the impact of customers as a definition of the severity of the event as this may lead to perverse incentives to extend the durations of the marginal events to meet the exclusion criterion. Each severe storm has different characteristics. The licensee should restore supply to the customers as soon as practicable during severe weather events.

NOTE 3 This will also assist in internal licensee and external NERSA auditing of the severe weather events, rendering them much simpler and more transparent.

NOTE 4 Given the infrequency of severe weather events it is not always financially possible or appropriate for licensees to be stretched beyond their limits in attempting to contain and control an abnormal event. It may be considered inefficient and sub-optimal use of regulated revenues which are ultimately funded by end customers, to equip licensees to effectively deal with the results of freak storms.

NOTE 5 The classification of an event as a severe weather event (major event) should be an auditable and transparent process.

5.3.3.5 Major event criterion D reporting (for internal licensee reporting)

The criteria shall be defined by the distribution licensee as part of its internal performance management and reporting process.

NOTE The criteria for internal performance management can be linked to the IEEE 2.5 Beta methodology (exclusion of days where the SAIDI performance for the day is more than a statistically calculated SAIDI per day threshold value) major event definition or any other licensee criteria deemed appropriate for internal performance management.

5.3.4 Third party

An unplanned interruption shall be categorized as a "third party" where an external person or company that is not part of the customer, or is contracted by the customer or by the distribution licensee, causes an unplanned supply interruption to occur on the licensee's networks.

5.4 Application of planned interruption category

5.4.1 General

Planned work activity categories are covered in NRS 082. For the purposes of this part of NRS 048, the planned work execution refers to all planned (corrective and preventative) work activities that result in an interruption of supply experienced by the customer.

NOTE Although not a minimum requirement, some distribution licensees may wish to log the positive impact of live work on planned work performance. A category for live work may therefore be utilitized and reported on. Live work provides a measure of the frequency and duration of the interruptions "saved" by working live on the section of network or plant. Typical examples of live work are line or cable repairs by use of the gloving technique, installation of bird guards on cross arms, spray washing of insulators and the changing of insulators done live with vehicles, etc.

5.4.2 Pre-arranged

A planned interruption shall be categorized as "pre-arranged" when the following applies:

An item of plant or section of network is deliberately and in a co-ordinated manner, taken out of service (by the distribution licensee or its appointed agent) at a selected date and time. All the affected customers shall have been notified of the planned interruption in accordance with the minimum period prescribed in NRS 047-1, or as otherwise contractually agreed upon.

NOTE 1 Planned work activity categories are covered in NRS 048-2.

NOTE 2 Currently NRS 047-1 specifies a 48 h planned interruption notification time for customers.

When the planned and co-ordinated interruption of supply to the customer or group of customers involves a number of successive switching operations that result in numerous interruptions, then the interruptions are all counted as a **single planned interruption**. The following requirements need to be noted and shall be implemented:

a) the supply needs to be restored to the customer on the notified time as originally scheduled. If the distribution licensee starts the interruption later than the notified time due to any reason, then the licensee has less time to complete the interruption, but the actual off time recorded will be based on the later start time;

b) the total duration of the interruption shall be recorded as the planned interruption time, unless the total duration of the interruption is longer that the notified time provided to the customer; then the longer actual duration time is to be used as the actual duration.

NOTE There needs to be a clear separation of the technical performance and quality of service related measures. The technical performance measures are based on the actual supply interruption times experienced by the customers. The quality of service measures are based on the scheduled interruption time by the licensee, that the customers are surveyed on in terms of their satisfaction. A measure of the number of planned interruptions finishing later than the notified time can be established in NRS 047-1 to provide a measure of the distribution licensee's quality of service provided.

5.4.3 Major event

A planned interruption shall be categorized as a "major event" where any one of the criteria specified in 5.3.3.1, 5.3.3.2 and 5.3.3.3 apply. This is due to the fact that the interruption which complies with the major event criteria can be either an unplanned or planned interruption, depending on the specific conditions and circumstances.

5.5 Application of customer related category

5.5.1 Customer caused

A customer related interruption shall be categorized as "customer caused" when an interruption of supply occurs on the distribution licensee's network and the interruption is caused directly by the customer concerned, or by the customer's appointed agent working on the customer's item of plant or network.

Any other customers affected by the same customer caused interruption will have their associated interruptions counted as unplanned interruptions.

NOTE 1 Typical examples of customer caused category interruptions are customer-planned work that is carried out on the customer's own plant, which causes a fault, or when a contractor, who was hired by the customer, causes a fault on the customer's plant.

NOTE 2 If a customer is disconnected owing to non-payment and re-connected, this is regarded as a customer caused event.

NOTE 3 It is the responsibility of the distribution licensee to ensure adequate planning and protection co-ordination to limit the impact of customer caused interruptions on the other nearby customers on the network (i.e. by ensuring that customers have installed adequate protection).

5.5.2 Customer requested

A customer related interruption shall be categorized as a "customer requested" when there is an interruption of supply requested by the customer for the maintenance or repair of their own plant, up-grading of equipment, or the refurbishment of the network.

Any other customers affected by the same customer requested interruption, will have their associated interruptions counted as unplanned or planned interruptions, depending on which is applicable.

NOTE Typical examples of customer requested category interruptions are customer planned work carried out on the customer's own plant, customer requested switching or operating, or customer requested unplanned ad hoc maintenance work by the distribution licensee at the substation.

5.6 Application of intake supply-related category

5.6.1 Unplanned

An intake supply related interruption shall be categorized as "unplanned" when there is an unplanned interruption of supply (or faults) occurring on the network of the distribution licensee, that was not caused directly by the affected licensee or its customer and their appointed agents. These interruptions are caused by generation, transmission, adjacent distribution or distributed generation licensees.

5.6.2 Planned

An intake supply related interruption shall be categorized as “planned” when there is a planned and coordinated interruption of supply occurring on the network of the distribution licensee that is not caused directly by the affected licensee or its customer and their appointed agents. This category is not only limited to maintenance activities, but also includes network extensions and customer connections. These interruptions are caused by other generation, transmission, adjacent distribution or distributed generation licensees.

The initiating generation, transmission, other distribution or distributed generation licensees of the planned supply interruption **shall inform** the affected distribution licensee of the planned interruption **at least seven working days** ahead of time, in writing, and direct the information to the responsible person.

5.6.3 Load shedding

An intake supply related interruption shall be categorized as “load shedding” when there is a planned and coordinated interruption of supply occurring on the network of the distribution licensee, that is requested by the generation or transmission licensee to conduct load shedding or swinging, in order to protect the security of the supply system (low frequency conditions) to the general customer base. This will result in customers experiencing interruptions of supply but the network security will be protected.

The seven working days notification requirement will not apply. These interruptions need to be carefully recorded, assessed and reported separately as they are not reflective of the underlying network interruption performance levels.

5.7 Related loss of supply and single phasing events

5.7.1 Voluntary and involuntary load reduction and load shedding events

Customer voluntary and involuntary load reduction events are characterized by the curtailment, partial curtailment, or reduction of customer load magnitude, but no actual interruption of supply occurs.

The actions are to reduce the load in order to protect the security of the supply system to the general customer base. Customer voluntary (including voluntary under-frequency load shedding) and involuntary (including mandatory under-frequency load shedding) load reduction events **shall not be** classified as interruptions, but shall be **assessed and reported** separately.

NOTE NRS 048-2 provides the requirements of voluntary and involuntary load reduction events.

5.7.2 Single phasing events

Where one or two phases to a three-phase customer are disconnected, and the duration is longer than 3 s, such an event is defined as a single phasing event by the distribution licensee. This is also loosely referred to as “single phasing” and shall be recorded as an unplanned interruption.

NOTE When there is a single phase MV fuse failure, the voltage supplied on LV networks may be significantly outside the limits as specified in NRS 048-2, until the problem is rectified.

5.8 Characteristic values of sustained interruptions

The characteristic values for planned and unplanned sustained interruptions are covered in NRS 048-2.

6 Definitions of network interruption performance indices

6.1 Introduction

The following network interruption performance indices provide measures of reliability and availability of supply related areas:

a) availability of supply – the average duration of an interruption of supply experienced by the customer;

b) reliability of supply – how frequently on average an interruption of supply is experienced by the customer;

c) restoration of supply – the percentage of customers that had their supply restored within a specified target time after an interruption (based on NRS 047-1 requirements);

d) worst served customers – the percentage of individual customers that receive poor network interruption performance levels;

e) MV transformer unavailability – the average duration of interruption of supply that affects the MV/LV transformers only; or

f) network reliability – the frequency of interruptions that occur on a network normalized to 100 km.

6.2 Sustained interruption indices

6.2.1 Automatic and manual intervention

The following network interruption performance indices and definitions all refer to sustained interruptions to MV and LV networks (> 5 min window). This time the requirement is to differentiate between an automatic (system) and manual (operator) intervention to restore network supply to the customer on the MV network.

The data capturing requirements are set out in 4.3.

NOTE The 5 min window for MV networks takes into account the potential communication delays in the SCADA system for remote terminal units (RTUs) on the low bandwidth area radio networks under loaded conditions and the circuit-breaker duty cycle second dead time (3 min) requirements of SANS 62271-100.

See annex B for an illustrated example of the network interruption performance index calculations.

6.2.2 Re-interruptions

The subsequent interruptions due to fault finding or network operating that are associated with the original network interruption shall be referred to as ”re-interruptions”. Re-interruptions only apply to unplanned related work. These subsequent interruptions need to be carefully considered, so that they are not unnecessarily included in the network interruption performance index calculations and unfairly penalize the distribution licensee with “double counting” of interruptions. Counting the subsequent interruptions due to fault finding and network switching unfairly penalizes the licensee and forces the incorrect behaviour and fault finding and restoration of supply practises from the field staff.

Any re-interruption shall occur **less than 3 h** after the first interruption and with the cause code of the interruption at the **same physical location on the network** as the original interruption. The actual interruption duration time will be used (sum of all the interruptions experienced), but the frequency will only be counted as one interruption. An interruption that occurs **3 h or longer** after

the previous interruption, will be **counted as a new interruption**, even if it occurs at the same location on the network.
A simplistic rule-of-thumb is provided below to promote the understanding on the re-interruption concept:

a) breaker trip – close – trip < 3 h: re-interruption;
b) breaker trip – close – trip ≥ 3 h: new interruption.

The above concept of a re-interruption can be illustrated by the following example. A MV network has a loss of supply for 1 h for all the connected customers, the whole network has supply restored for 30 min (assuming no step restoration), the whole network has a further loss of supply for 30 min, the entire network then has supply permanently restored. The network event would be reported as all the customers having experienced one sustained interruption for a total duration of 2 h.

NOTE 1 The purpose of the re-interruption concept is to clearly distinguish between a supply interruption due to a new event and an interruption due to network switching or fault finding by the licensee, in order to restore supply to the customer as soon as possible after a fault. The distribution licensee is still encouraged (and in future incentives will be made available) to restore supply to the customers in the shortest possible time through distribution automation, reduced travelling time, etc.

NOTE 2 The international average for customer average interruption duration index (CAIDI) is around 2 h. Setting a re-interruption time window as 3 h would therefore be appropriate. The UK regulator (OFGEM) also specifies a re-interruption time of 3 h.

NOTE 3 The distribution licensees need to also implement internal circuit-breaker duty cycle practises to ensure a sound engineering and economic balance between the breaker life (number of breaker operations) and reduced interruption durations (shorter response times).

NOTE 4 The practise of re-interruptions will result in a statistical step increase in the current SAIDI levels and a statistical step decrease in the current SAIFI levels of a distribution licensee. This will result in reported SAIFI and SAIDI values that are more accurate and controllable through appropriate improvement strategies to be implemented. This will require the recalculation of historical data and the recalibration of targets to reflect the adjusted data.

NOTE 5 A potential future IBR environment (similar to the UK IBR environment) could be a focus on both SAIFI and SAIDI over the incentive period (three to ten years), but with more emphasis on improving SAIDI. The SAIFI could be sustainably improved by 0,5 % to 1,0 % per annum with SAIDI sustainably improved by 15 % to 30 % over the incentive period. To improve SAIFI requires a long-term approach while improving SAIDI can be done over the short to medium term. It should be noted that IBR does not only relate to technical performance but to an entire business efficiency and mobilization step change that cuts across all the departments, value chains, processes, systems, data, financial and human resource aspects of a distribution licensee.

6.2.3 SAIFI (System Average Interruption Frequency Index)

The SAIFI of a network indicates how often the average customer connected would experience a sustained interruption per annum. This excludes re-interruptions. Mathematically SAIFI can be expressed as:

$$\text{SAIFI} = \frac{\text{Total number of customer interruptions p.a.}}{\text{Total number of customers served}} \quad (1)$$

6.2.4 SAIDI (System Average Interruption Duration Index)

The SAIDI of a network indicates the duration of a sustained interruption the average customer would experience per annum. This excludes re-interruptions. It is commonly measured in customer minutes or customer hours of interruption. Mathematically SAIDI can be expressed as:

$$\text{SAIDI} = \frac{\sum \text{customer interruption durations p.a.}}{\text{Total number of customers served}} \quad (2)$$

6.2.5 CAIDI (Customer Average Interruption Duration Index)

The CAIDI of a network indicates the duration of a sustained interruption that only the customers affected would experience per annum. This excludes re-interruptions. It is commonly measured in customer minutes or customer hours of interruption.

This index differs from SAIDI in that only the number of affected customer interruptions is used in the denominator and not the total number of customers served. CAIDI is also the ratio of SAIDI and SAIFI. Mathematically CAIDI can be expressed as either

$$\text{CAIDI} = \frac{\sum \text{customer interruption durations p.a.}}{\text{Total number of customer interruptions}} \quad (3)$$

or expressed as:

$$\text{CAIDI} = \frac{\text{SAIDI}}{\text{SAIFI}} \quad (4)$$

NOTE The general case is for CAIDI < SAIDI, as CAIDI only takes into account the number of affected customers. CAIDI is also the measure used to measure the average customer restoration times.

6.2.6 CAIFI (Customer Average Interruption Frequency Index)

The CAIFI of a network indicates how often only the customers affected by an interruption experience a sustained interruption per annum. The customer is counted only once in this calculation, regardless of the number of times he experienced an interruption in the reporting period.

This index differs from SAIFI in that only the number of customer interruptions is used in the denominator and not the total number of served customers. Mathematically CAIFI can be expressed as:

$$\text{CAIFI} = \frac{\text{Total number of customer interruptions p.a.}}{\text{Total number of customers interrupted}} \quad (5)$$

6.2.7 ASAI (Average Service Availability Index)

The ASAI represents the fraction of time (often expressed as a percentage) that a customer has received supply during one year. ASAI is a useful index for measuring the availability of supply of customers with firm supplies. Mathematically ASAI can be expressed as:

$$\text{ASAI} = \frac{\text{Customer hours service availability p.a.}}{\text{Customer hours service demand p.a.}} \quad (6)$$

NOTE There are 8 760 hours in a non-leap year and 8 784 h in a leap year.

Alternatively ASAI can be expressed as:

$$ASAI = 1 - \frac{SAIDI}{8760} \quad (7)$$

6.2.8 MSLI (MV Supply Loss Index)

The MSLI of a network indicates the average transformer supply loss duration of the MV plant installed due to sustained interruptions. It is a measure of the MV transformer unavailability and is expressed as hours per month. Only the MV supply transformers are used as part of the calculation and MV coupling transformers are excluded. The MSLI will also include MV plant that has been affected by LV and HV related interruptions on the network.

Mathematically MSLI can be expressed as:

$$MSLI = \frac{\sum \text{MVA.Hours.lost per month}}{\text{Installed MV MVA base}} \quad (8)$$

6.2.9 Sustained faults/100 km (number of faults per 100 km)

The number of sustained faults per 100 km of a network indicates the total number of sustained faults experienced normalized per 100 km of circuit length per annum.

Mathematically faults/100 km can be expressed (separately per voltage category) as:

$$\text{Sustained faults/100 km} = \frac{\text{Sustained faults p.a. x 100}}{\text{Total line length (km)}} \quad (9)$$

NOTE 1 Cable and overhead lines should be reported separately.

NOTE 2 Faults do not include planned interruptions.

6.3 Momentary interruption indices

6.3.1 General

The following network interruption performance index definitions all refer to momentary interruptions on MV networks (≤ 5 min). The indices are a measure of the transient interruption performance of a network, or the auto-reclose (ARC) performance of the circuit-breakers.

The number of customers affected that are identified shall be in the same manner and accuracy as for sustained interruptions. If the distribution licensee uses a method of periodic counting of recloser operations (for instance monthly planned downloads), then the number of customers interrupted will be based on an estimate of those customers interrupted for a 12 month window.

The particular network configuration (normally open points, etc.) can be assumed but the assumptions shall be provided in any report submissions. Otherwise, the licensee shall provide accurate and reliable information on the actual network configuration at the time.

6.3.2 MAIFI (momentary average interruption frequency index)

The MAIFI of a network indicates how often the average customer served would experience a momentary interruption per annum. Mathematically MAIFI can be expressed as:

$$\text{MAIFI} = \frac{\text{Total number of customer momentary interruptions p.a.}}{\text{Total number of customers served}} \quad (10)$$

6.3.3 MAIFIe (Momentary Average Interruption Frequency Index of events)

The MAIFIe of a network indicates how often an average customer connected would experience a momentary event per annum. A momentary event may comprise one or more momentary interruptions.

If two or more breaker reclose operations (ARCs) or momentary interruptions occur within the relevant window period for the MV definitions, these interruptions will be considered as part of the momentary event and will only be reported as a single momentary event. This applies to multi-shot reclosing schemes that have a sequence of multiple momentary interruptions. The distribution licensee shall ensure that all the on and off times are recorded.

Mathematically MAIFIe can be expressed as:

$$\text{MAIFIe} = \frac{\text{Total number of customer momentary interruption events p.a.}}{\text{Total number of customers served}} \quad (11)$$

6.3.4 Momentary faults/100 km (number of faults per 100 km)

The number of momentary faults per 100 km of a network indicates the total number of momentary faults experienced normalized per 100 km of circuit length per annum.

Mathematically faults/100 km can be expressed (separately per voltage category) as:

$$\text{Momentary faults/100 km} = \frac{\text{Momentary faults p.a. x 100}}{\text{Total line length (km)}} \quad (12)$$

NOTE Faults do not include planned interruptions (e.g. during switching).

6.4 Worst served customers measures

The worst served customer related indices ensure that the network interruption performance levels experienced by individual customers are still within the reasonable expected performance levels. The objective is to report reliability and availability of supply trends as given by the two measures below that are reflective of the network interruption performance of individual customers. This includes planned and unplanned components.

It will be necessary to determine the following indices:

a) percentage of customers with single supply sustained interruptions of longer than a specified number of hours per annum per event, and

b) percentage of customers who experience more than a specified number of sustained interruptions per annum.

NOTE 1 The sustained interruption calculation definitions and calculating method should be applied.

NOTE 2 The quantum for the above needs to be established by the relevant licensee in consultation with NERSA.

NOTE 3 Customer caused faults are not included in the above.

NOTE 4 The distribution licensee is accountable for the effective management of its poor or worst performing networks (or sometimes loosely referred to as “rogue feeders”). The criteria for identifying the worst performing networks are based on a certain percentage of networks that may be internally driven (i.e. five to ten percent of networks above a limit for SAIFI or SAIDI) or externally driven (NERSA introducing IBR mechanism that focuses on SAIDI).

6.5 Customer supply restoration times

The following information shall be the methodology to be applied by all the distribution licensees for the calculation of customer supply restoration times after an unplanned interruption for the required NRS 047-1 reporting:

a) the unplanned sustained interruptions will only be counted for the restoration time calculations. The individual customer hours affected will be used for the calculations;

b) the restoration time will be defined as from the first time the individual customer was affected to the last restoration time of that customer. It will be assumed that the customer off time will be the same as the event time off time;

The individual customer interruptions will be summated and a count of the number of customers affected performed according to the NRS 047-1 defined categories.

c) the results will be expressed cumulatively and as a percentage of the total number of customers interrupted, and drawn on the required graph format. The X-axis will have the NRS 047-1 restoration time categories and the Y-axis will have the percentage of customers with supply restored. See the example below for clarity.

NOTE The current NRS 047-1 duration categories are 1,5 h, 3,5 h, 7,5 h and 9,5 h.

Figure 1 provides an example of the NRS 047-1 restoration of supply times after unplanned interruptions. Distribution licensee A has good restoration of supply times while distribution licensee B has poor restoration of supply times (does not comply with the NRS 047-1 requirements).

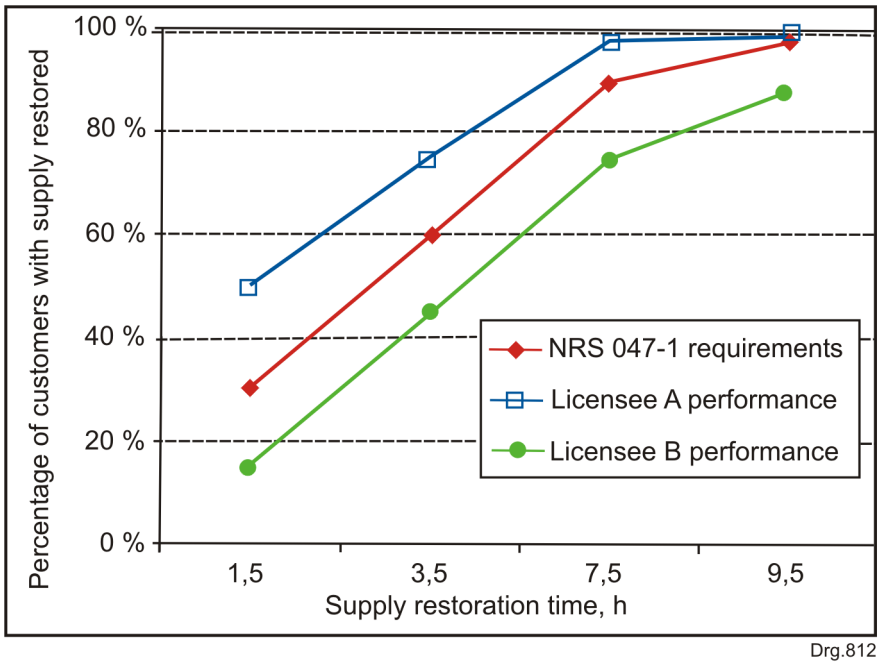


Figure 1 — Example of NRS 047-1 – Restoration of supply times after unplanned interruptions

7 Network event data auditing and validation

7.1 Network events to be validated

All the following network events shall be validated and confirmed by the distribution licensee:

a) network events that affect the connected customers;

b) network events that result and that do not result in a loss of supply;

c) network secondary plant, protection and alarms;

d) network momentary and sustained interruptions; and

e) network planned work and unplanned interruptions.

The network events that result in an interruption of supply need to be carefully validated and an audit trail provided.

7.2 Network event and interruption times

7.2.1 Network event start time

The network event start time shall be the earlier date and time at which either of the following occur:

a) the first report of loss of supply of a network or of a customer, or the report of an item of equipment that has faulted on a section of the network; and

b) network or equipment that is automatically or intentionally disconnected from the system.

7.2.2 Interruption start times

The interruption of supply start time shall be the earlier date and time at which either of the following occur:

a) the customer or a third party contacts the licensee to inform him of the interruption;

b) an automatic alarm received by the licensee that indicates an interruption; and

c) a staff member of the licensee that identifies the existence of an interruption.

7.2.3 Interruption end times

The interruption end time is the actual date and time at which supply was restored back to the customer. The following conditions shall be applied:

a) supply has been restored to all the affected customers for **3 h and longer**. An interruption that occurs after 3 h or longer after the previous interruption, shall be counted as a new and separate interruption; and

   NOTE This needs to be a permanent restoration of supply and not a temporary restoration of supply due to fault finding, restoration of supply or repair work.

b) if there is a further loss of supply due to an unrelated network event with different cause or on an adjacent network, then this should be counted as a new and separate interruption.

7.3 Clock stopping for end times

The counting of the duration of the interruption shall be “clock stopped” when either of the following occurs:

a) if access to the customer or substation is not available or prevented despite the best efforts of the distribution licensee to gain access. The clock should be started again as soon as access is obtained. The licensee should keep accurate and reliable records about the delay and reasons for accessing the customer or substation. These records shall be made available to be audited on request by the customer or the NERSA;

b) if a customer requests that the restoration of supply is to be stopped for a requested period of time. The clock should be started again as soon as the requested delay by the customer has expired. The licensee should keep accurate and reliable records about the requested delay by the customer. These records shall be made available to be audited on request by the customer or the NERSA;

c) when the restoration of supply is to be stopped due to safety issues, life-threatening situations, emergency services, government authorities or other licensees who prevent access or request the restoration of supply to be stopped or put on hold. The licensee should keep accurate and reliable records about the requested delay by the customer. These records shall be made available to be audited on request by the customer or the NERSA.

7.4 Permission to operate (PTO) and permission to close (PTS)

All PTOs and PTSs shall be manually captured after the interruption. The distribution licensee shall ensure that the dates and supply on and off times are accurately and reliably captured. These records shall be made available to be audited on request by the affected customer or the NERSA. The distribution licensee shall implement an appropriate monthly validation process of all PTOs and PTSs issued.

7.5 Number of customers affected

The number of customers affected shall be determined from the customer connectivity model and sound engineering judgement. The number of customers and transformers affected for the relevant section of network needs to be determined. These records shall be made available to be audited on request by the customer or the NERSA.

7.6 Data validation of events

7.6.1 General

The process of validating the data for network events depends on the event type. An event can either be an unplanned interruption or planned work. The product of the number of customers affected and the duration of the interruption (expressed as MVA.Hours) needs to be analysed accurately as this impacts on the accuracy of the network interruption performance measures.

7.6.2 Unplanned interruptions

This type of event is characterized by switching operations that are triggered by protection equipment and frequently by equipment failure. The licensee shall ensure that all the switching operations are present for clearing the fault and for restoring the supply to the network. This can be done by auditing and analysing the details of the field work operating logs. The chronological sequence of these operations is as important as the actual event itself.

These operations will determine the losses result obtained when the event is traced. The licensee shall determine that the switching sequence is valid and practically possible for the customers

affected and for the network configuration. The location, operation type and cause descriptions shall be relevant to the event and associated network operations.

7.6.3 Planned work

Planned work events are events that occur on the network due to maintenance or refurbishment conducted on the network or where the network was isolated for construction purposes.

The licensee shall ensure that all the switching operations are **predefined and present before** the network is being isolated. The chronological sequence of these network operations is as important as the network operation itself.

7.6.4 Event tracing

Event tracing is the process followed to determine the number of MVA hours lost and the number of transformers and associated customers affected by a network interruption of supply. There are two forms of tracing, automatic tracing and manual tracing. Automatic tracing is used to determines the sum of the transformer capacities and the number of customers affected by a switching network operation.

By using the network operation details linked to the event, the calculation leads to the number of MVA hours lost and the number of customers affected. The tracing is conducted automatically by a software system. The automatic tracing application determines the durations that the transformers or customers were affected, from the start of the network operation and the end date algorithms.

Manual tracing implies that a user shall manually determine which transformers and customers were affected and the durations of their being affected. This requires a user to examine all available information to validate an event.

The planned work, conducted live work and related events can be included in this tracing as the losses recorded are interpreted as ”savings” by the licensee.

7.6.5 Transformers affected

All transformers shall be recorded where supply to the network was affected. The user shall by examining the effect of the network operations on the network, determine the number and ratings of transformers and the number of customers that were affected by the interruption of supply.

The following applications, as specified in annex C, shall be implemented by the distribution licensee:

a) where parallel transformer configurations exist, the network event will only be recorded if the connected customers are affected by the interruption; and

b) if a customer has two or more switching points beyond a breaker and the customer requests switching of one of those points, then all the other switching points affected by that single point switching will be classified as a customer requested interruption.

7.6.6 Affected durations

The durations that transformers and customers are being affected, are not necessarily the same durations as the switching network operations start and end times. When the automatic trace facility is being utilized for an event, the system determines the actual affected duration times for transformers and customers. The user shall accurately determine these durations by analysing the effect of the switching times of the plant on the transformers, for manual tracing.

This process of analysis can best be described as ‘timeline analysis’ and should be used where several network operations are present for a single event. Timeline analysis assists the user in determining the correct off and on times to which the plant and customers have been subjected.

8 Interruption cause code categories

8.1 Introduction

This clause presents a minimal set of data codes and a consistent categorization structure necessary for interruption cause code collection, reporting and the comparison of distribution network performance in South Africa. There are 14 identified primary cause codes (A to N) and corresponding secondary cause codes to provide high level information about the cause of supply interruptions, ensure a common interpretation, and assist in the uniform and consistent reporting of all the distribution licensees.

The licensee is required to conduct plant failure investigations and ensure that the cause codes of supply interruptions are updated at a later stage when the actual cause is found or additional information is available.

NOTE 1 The proposed interruption cause code hierarchy is not a detailed or formal root cause analysis tool, but only a high level tool to categorize the causes of interruptions into logical and systematic categories to assist with identification of potential problem areas and the application of mitigation projects or improvement initiatives.

NOTE 2 Broad categories were intentionally established to help minimize data collection efforts by distribution licensees. There are numerous other categories that could be selected, but with the goal of uniformity and simplicity for comparison purposes and practicality, the above primary and secondary cause codes were selected. Allowance is made for those causes not covered (another category) and those causes that are unknown (unknown category)

NOTE 3 The interruption cause code categories will assist in future interruption performance benchmark exercises, so it is critical that accurate and reliable data is captured by the distribution licensees.

8.2 Overview of categories

8.2.1 Equipment failure

The following shall apply:

a) failure of cable circuit (including any terminations to lines or other circuits);

b) failure of overhead line (including associated equipment, but excluding transformers);

c) failure of a transformer (including tap-changers and voltage regulators);

d) failure of reactive control devices (capacitor, reactors);

e) failure of switchgear;

f) failure of terminal equipment and sundry substation plant (busbars, lightning arresters and instrument transformers, etc.);

g) protection system failure (fuse failure);

h) control system failure (SCADA); and

i) other.

NOTE 1 The cable category includes joints, terminations, ferrules and lugs.

NOTE 2 The transformer category includes auxiliary, current, distribution, grounding, potential or voltage, power, rectifying, step-down/conversion, and voltage regulating transformers.

NOTE 3 The distribution licensee may have sublevels of the above high level categories.

8.2.2 Planned work

The planned work category includes all interruptions that are carried out as planned. This also takes into account planned work that extends beyond the notified period.

8.2.3 Operational causes

The following apply:

a) incorrect protection operation (settings/fuse sizing);

b) incorrect control equipment operation;

c) licensee's operator error or licensee's contractor error; and

d) emergency.

8.2.4 Supply intake (non-distribution licensee caused)

The following apply:

a) loss of supply due to technical problem; and

b) loss of supply due to non-payment.

8.2.5 Vegetation

The "Vegetation" category includes interruptions caused by trees that have fallen and trees that have grown into lines. It should be noted that if a tree is involved, the cause category is "Vegetation". This is important to note during wind storms. It might not be possible to determine that a network had a forestry issue if "wind" was listed as the cause, when actually a tree was involved. Interruptions caused by the combination of wind and vegetation shall be recorded under this category.

8.2.6 Fire

The following apply:

a) sugar cane fires; and

b) veld or bush fire.

8.2.7 Natural events

The following apply:

a) storm (lightning or wind);

b) snow or ice; and

c) significant events (earthquakes and tornadoes).

8.2.8 Insulation pollution

The following apply:

a) industrial;

b) natural (e.g. salt air, excluding bird);

c) fire-related; and

d) other.

8.2.9 Wildlife

The following apply:

a) birds (physical contact / bird streamers / pollution, etc.); and

b) other.

8.2.10 Customer

8.2.11 Theft and vandalism

8.2.12 Third party

Includes cables ripped or dug up by contractors, and collisions.

NOTE If a tree outside a servitude of a line is felled by others and results in contact with the overhead line, this is classified as a third party category.

8.2.13 Unknown

The “unknown” category includes any interruptions where a definitive cause cannot be determined even after a formal investigation. The distribution licensee shall provide a brief description of each interruption assigned to the “Unknown” category. The number of interruptions classified as “Unknown” shall be kept to a practical limit.

8.2.14 Other

Any interruptions that do not fall into any of the above primary cause code categories should be assigned to the “Other” category. The distribution licensee shall provide a brief description of each interruption assigned to the “Other” category. The number of interruptions classified as “Other” shall be kept to a practical limit.

NOTE Distribution licensees are encouraged to record the interruptions of supply under their own subsets of the above key categories for performance management purposes.

9 Data and change management

9.1 General

Future regulatory requirements might require different forms of historical data to be accessed. It is required that interruption performance data be managed, as minimum requirements, in accordance with the levels described in 9.2 to 9.5.

9.2 Data archiving

Interruption performance data for reporting shall be retained for a minimum of five (5) years in a format that allows for:

a) retrieval by network, substation, district/area, and total system;

b) retrieval of the raw event data details and cause codes per event per network per day.

9.3 System changes

A detailed record of software or system-related changes to the data reporting shall be kept, including:

a) the nature and impact of the change;

b) the date from which the change was implemented;

c) the business reasons for the change;

d) a demonstration of the “before” and “after” impact of the data change with at least 12 months of data used to illustrate the impact.

The intention is for the distribution licensee to be able to reliably and accurately demonstrate the impact of any software program-related changes on the network interruption performance levels (for instance explain a step change in the SAIFI level due to data or system changes).

9.4 Accuracy guidelines for interruption reporting

The accuracy of network interruption performance measures will be critical in future IBR environments and annual regulatory reporting. The information below will apply once the systems are functional and there is confidence in the reported measures.

The distribution licensee shall be required to have a minimum accuracy level of 95 % for the number of customers interrupted and 95 % for the duration of interruptions of supply.

The accuracy levels apply to both HV and MV connected customers who experience sustained interruptions. The licensee shall comply with the accuracy levels for the number of customers interrupted and the duration of interruptions of supply.

The distribution licensee shall ensure the appropriate levels of completeness and accuracy of the levels of interruption performance reported. This can be determined by an audit at the end of each reporting period. The distribution licensee shall have the customer network link greater than or equal to 95 % in the reporting period.

NOTE 1 The initial accuracy level of 95 % may be relaxed to take into account the current data connectivity model and data maturity of the licensee.

NOTE 2 It is proposed that the licensee will conduct a self-audit annually, but this may become a future regulatory requirement. The reporting accuracy levels will be critical once IBR has been implemented.

NOTE 3 The accuracy levels of HV and MV networks required may be increased in future regulatory requirements. It is also possible that accuracy levels for LV networks and for momentary interruptions will be introduced in the future.

9.5 Estimating methodology for the accuracy of annual interruption reporting

9.5.1 General

There is a concern that the duration of interruption could be manipulated by distribution licensees in order to artificially create particular types of networks event, i.e. momentary or sustained interruptions, which may not be supported by the actual failure and supply restoration processes. This will require an accuracy assessment process.

9.5.2 Step 1

External or internal auditors (for self-auditing) are appointed to conduct the accuracy of interruption performance reporting audits by distribution licensees. The auditors are to randomly select a sample size of (e.g. 50 HV and 100 MV related network events) for sustained interruptions of the reporting period (calendar year). Where events are “too difficult” to audit, they are to be substituted with another event on the same network and similar time period, as the previously selected event. An event with no data attached is not to be regarded as “too difficult” to audit and is indicative of poor interruption performance accuracy.

9.5.3 Step 2

The auditors shall manually audit each event and determine the audited interruption of supply restoration time and the audited number of customers affected. The auditors are to calculate the error between the reported interruption restoration time and number of customers affected and the audited interruption restoration time and number of customers affected. The auditors will then calculate the mean, standard deviation and the mean plus/minus four (4) standard deviations of the errors. The auditors shall exclude any events that contain statistical outlier interruption restoration times or numbers of customers affected (where the error calculated is outside the mean plus/minus four standard deviations).

9.5.4 Step 3

The auditors will estimate the reporting of interruption duration accuracy and the reporting of customer number affected accuracy, for the remaining HV and MV samples (that are within the outlier restoration times and customer numbers) using the formulae below. The outlier events are excluded.

$$\text{Reporting Duration Accuracy \%} = \frac{\text{Sum of reported interruptions of supply duration}}{\text{Sum of audited interruptions of supply duration}} \times 100 \qquad (13)$$

$$\text{Reporting Customer Number Accuracy \%} = \frac{\text{Sum of reported customer numbers affected}}{\text{Sum of audited customer numbers affected}} \times 100 \qquad (14)$$

9.5.5 Step 4

If the network interruption performance reporting accuracy is **≥ 95** %, the licensee will be deemed to have met the necessary reporting accuracy levels. If the overall reporting accuracy is **less than 95** %**,** the reported network interruption performance levels will be adjusted to reflect a **100** % reporting accuracy level. This means that the interruption restoration time based indices and number of customer affected indices may be adjusted to reflect a calculated 100 % level of accuracy. This is to encourage the licensee to internally, effectively and holistically manage the accuracy of the validation and quality assurance processes of its interruption performance measures and underlying raw event data.

The distribution licensee will be required to have a minimum accuracy level of 95 % for the number of customers interrupted and 95 % for the duration of interruptions of supply. The accuracy levels

apply to both HV and MV connected customers that experience sustained interruptions. The licensee shall comply with both the accuracy levels for the number of customers interrupted and the duration of interruptions of supply.

The above concept of network performance level adjustment due to low report accuracy levels can be illustrated by the following example.

An audit is undertaken and calculates an SAIDI = 50,0 h per annum, but at a reporting accuracy of 90 %. The adjusted SAIDI to reflect a 100 % reporting accuracy is calculated to be SAIDI = 55,6.

10 Requirements for the reporting of network interruption performance

10.1 Application requirements for licensees to exclude valid major events

In cases where the licensee submits an application to exclude valid major events from performance reports, the following shall be provided:

a) a title page with the relevant licensee management's physical signatures provided;

b) a description of the major event and a summary of the events and circumstances around the major event. The declared start and end dates and times of the major event shall be provided;

c) an explanation as to why the event was not under the licensee's direct control, and why it should be excluded from the normal operational performance levels;

d) a summary of the actual escalation of the event through the licensee's management structure or the emergency process followed by the licensee and the responsible people involved;

e) the customers affected who were clearly flagged and ring fenced;

f) the relevant major event category for assessment;

g) the design criteria and operating environment, the design and construction of the affected network;

h) an impact analysis of the network performance measures or QoS measures (including and excluding the event to be discounted) and the impact on the licensee's targets;

i) the key lessons learnt and the mitigation or improvement plans to be implemented by the licensee to prepare for future similar events; and

j) any other relevant information that will increase the merits of the case and assist in the assessment of the application.

10.2 Requirements for annual power quality reporting

10.2.1 Annual reporting

Annual reporting to NERSA shall be on a calendar year basis for all licensees.

NOTE Synchronized reporting ensures that common events, which affect various licensees, are reported and consolidated for the industry for the same period, by NERSA.

10.2.2 System interruption performance statistics

10.2.2.1 The distribution licensee should report the network interruption performance information in 10.2.2.3 to 10.2.2.6 as part of the annual power quality (PQ) report to NERSA.

10.2.2.2 The system level performance reported shall be calculated as the customer weighted average of the relevant districts or areas.

10.2.2.3 Interruption performance measures

The licensee shall negotiate with NERSA the specific requirements for reporting

a) SAIFI,

b) CAIFI,

c) SAIDI,

d) CAIDI,

e) MSLI,

f) interruptions per 100 km (overhead and underground networks reported separately),

g) MAIFI,

h) MAIFIe,

i) momentary interruptions per 100 km (overhead and underground networks reported separately),

j) worst served customers,

k) customer supply restoration times,

l) the number of major events that occur per category, the impact of the major event on the indices, the supply received by the affected customers in a geographical area and the comprehensive investigation report that deals with the cause of each major event, and

m) the number of voluntary and involuntary load reduction events and the relevant information of each event.

10.2.2.4 High level categories

The reported interruption performance indices in 10.2.2.3 shall be reported separately as the following categories:

a) unplanned interruptions;

b) planned interruptions;

c) overall performance (unplanned, planned components and combined);

d) MV (where applicable); and

e) 33 kV (where applicable).

10.2.2.5 High level pareto contribution analysis reporting

The reported interruption performance indices shall be reported (number and percentage) separately as the following categories:

a) major events;

b) intake supply;

c) customer caused or requested;

d) third party; and

e) distribution licensee controlled measures (sum of all the other categories of supply interruptions).

NOTE 1 The sum of (a) to (e) above should be equal to the total number for the index.

NOTE 2 It is recommended that only SAIFI, SAIDI and MSLI are reported based on their pareto analysis contributions.

10.2.2.6 Categories for exclusion

The following shall be excluded from interruption performance indices, but the relevant information shall be reported separately:

a) customer caused and requested interruptions;

b) intake supply related interruptions;

1) non-load-shedding related,

2) load-shedding related.

10.2.3 Customer numbers reporting

The distribution licensee shall report the total number of customers whose electricity supplies are connected to the licensee's network in the relevant reporting year, with its annual interruption performance submission. The distribution licensee shall clearly define and describe the customer count methodology to the NERSA.

NOTE NERSA needs to define the 12 month period appropriate start and end dates.

10.2.4 Total length of network

The distribution licensee shall provide the NERSA with the following network lengths:

a) the total length of overhead circuit in kilometre, per voltage level (MV and LV);

b) the total length of underground cable per voltage level (MV and LV);

c) ABC aerial bundled conductor per voltage level (i.e. LV and MV).

For each voltage level, the sum of the three (3) asset categories above should be equal to the total network length. The circuit length, in kilometres, shall be estimated where precise information is unavailable.

10.2.5 Sum of installed transformer capacity

The distribution licensee shall provide the NERSA with the following transformer information:

a) the total number of transformers for MV and LV;

b) the sum of transformer capacity, in megavolt amperes, for MV and LV (transformer nameplate information shall be used).

These requirements exclude all coupling transformers. Transformers shall be grouped according to their primary voltage, and nominal ratings shall be used to calculate installed capacity.

10.2.6 Areas of distribution reporting

A distribution licensee shall provide the NERSA with a separate return for each logical area of electricity distribution within its licensed area of supply. Where there is any doubt as to what constitutes a logical area of supply, the NERSA should be consulted for a ruling. A licensee shall obtain the agreement of NERSA for any planned changes for the purpose of reporting, in the demarcation of logical areas of distribution. Any such changes may require an accurate recalculation of historical performance for such new areas, and for this reason a licensee shall be able to undertake such revised calculations.

NOTE For example Eskom Distribution would submit a separate return for each of its six distribution regions, and a metropolitan area with four substructures would provide a separate return for each substructure.

10.2.7 Technical commentary and cause codes

The following additional key information shall also be reported by the licensee:

a) a technical commentary report on the network interruption performance levels and explanation of any poor performance with the relevant action plans or initiatives to improve the performance; and

b) the interruptions experienced per cause code, with a technical commentary.

10.3 Reporting for incentive based purposes

The licensee shall report performance against incentive targets to NERSA for each new financial year.

Planned and unplanned interruption indices shall be reported separately.

NOTE 1 Reporting on a financial year basis ensures that financial and technical performance requirements are aligned for the relevant period.

The following categories of events may be excluded in the reporting of incentive based performance:

a) major events (which shall be reported individually);

b) intake supply related events;

c) customer related events;

d) voluntary and involuntary load reduction events; and

e) customer caused or requested interruptions.

NOTE 2 These events may be considered as not being directly under the control of the distribution licensee. It is anticipated that the NERSA will determine, in consultation with distribution licensees, which of these categories of network interruption performance indices are to be used in the incentive based regulation.

10.4 Reporting for benchmarking purposes

Network interruption performance reporting for benchmarking requires careful consideration of not only physical conditions related to the peer group members (e.g. network type and topography, environment, geography and network operating practises), but also of the measurement and reporting methods used.

Annex A
(informative)

Standard industrial classification (SIC) codes for customer categories

A.1 Agricultural, hunting, forestry and fishing

A.1.1 Agriculture, hunting and related services.

A.1.2 Forestry, logging and related services.

A.1.3 Fishing, operation of fish hatcheries and fish farms.

A.2 Industrial mining and quarrying

A.2.1 Mining of coal and lignite.

A.2.2 Extraction of cure petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying.

A.2.3 Mining of gold and uranium ore.

A.2.4 Mining of metal ores, except gold and uranium.

A.2.5 Other mining and quarrying.

A.2.6 Service activities incidental to mining of minerals.

A.3 Industrial manufacturing

A.3.1 Manufacture of food products, beverages and tobacco products.

A.3.2 Manufacture of textiles, clothing and leather goods.

A.3.3 Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials; manufacture of paper and paper products; publishing, printing and reproduction of recorded media.

A.3.4 Manufacture of coke, refined petroleum products and nuclear fuel; manufacture of chemicals and chemical products; manufacture of rubber and plastic products.

A.3.5 Manufacture of other non-metallic mineral products.

A.3.6 Manufacture of basic metals, fabricated metal products, machinery and equipment and of office, accounting and computing machinery.

A.3.7 Manufacture of electrical machinery and apparatus.

A.3.8 Manufacture of radio, television and communication equipment and apparatus and of medical, precision and optical instruments, watches and clocks.

Annex A
(continued)

A.3.9 Manufacture of transport equipment.

A.3.10 Manufacture of furniture; manufacturing; recycling

A.4 Industrial electricity, gas and water supply

A.4.1 Electricity, gas, steam and hot water supply.

A.4.2 Collection, purification and distribution of water.

A.5 Industrial construction

Construction

A.6 Commercial, wholesale and retail trade; repair of motor vehicles, motor cycles and personal and household goods; hotels and restaurants

A.6.1 Wholesale and commission trade, except of motor vehicles and motor cycles.

A.6.2 Retail trade, except of motor vehicles and motor cycles; repair of personal and household goods.

A.6.3 Sale maintenance and repair of motor vehicles and motor cycles; retail trade in automotive fuel.

A.6.4 Hotels and restaurants.

A.7 Commercial transport, storage and communication

A.7.1 Land transport; transport through pipelines.

A.7.2 Water transport.

A.7.3 Air transport.

A.7.4 Supporting and auxiliary transport activities; activities of travel agencies.

A.7.5 Post and telecommunication.

A.8 Commercial, financial, intermediation insurance; real estate and business services

A.8.1 Financial intermediation, except insurance and pension funding.

A.8.2 Insurance and pension funding, except compulsory social security.

A.8.3 Activities auxiliary to financial.

A.8.4 Real estate activities.

Annex A
(concluded)

A.8.5 Renting of machinery and equipment, without operator and of personal and household goods.

A.8.6 Computer and related activities.

A.8.7 Research and development.

A.8.8 Other business activities.

A.9 Commercial, community, social and personal services

A.9.1 Public administration and defence activities.

A.9.2 Education.

A.9.3 Health and social work.

A.9.4 Other community, social and personal services activities.

A.9.5 Activities of membership organizations.

A.9.6 Recreational, cultural and sporting activities.

A.9.7 Other service activities.

A.10 Private households, exterritorial organizations, representatives of foreign governments and other activities not adequately defined

A.10.1 Private households with employed persons.

A.10.2 Exterritorial organizations.

A.10.3 Representatives of foreign governments

A.10.4 Other activities not adequately defined.

Annex B
(informative)

Example of network interruption performance index calculations

B.1 Introduction of the scenario

The example below illustrates the correct calculation method of the network interruption performance indices, based on the assessment of a theoretical example. The impact of the pre-arranged planned work concept on the network interruption performance levels is also illustrated to further promote the understanding of the concept.

B.2 Network diagram

The field services department of a distribution licensee is doing planned maintenance by replacing the insulators on the network spur (section of line) from the SR136/1 links (see figure B.1). With the network diagram in figure B.1, the network interruption performance calculation method is explained in B.3 and B.4. Table B.1 provides a summary of the plant switching report

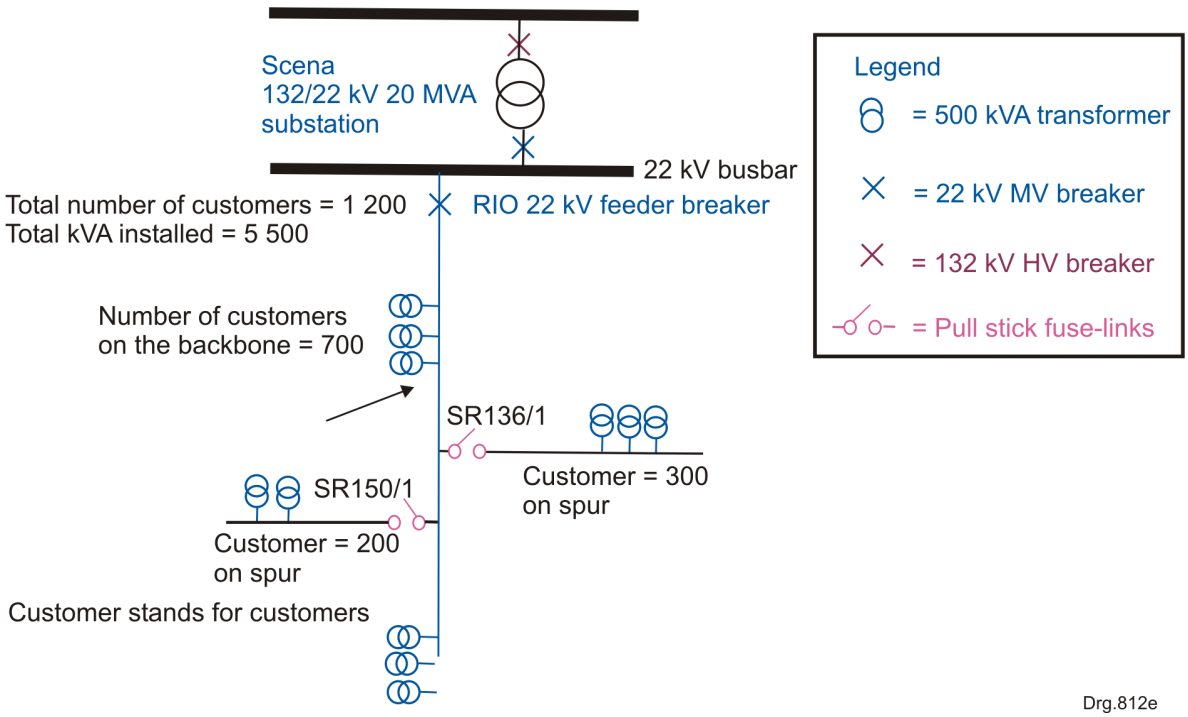


Figure B.1 — Example network

Annex B
(continued)

Table B.1 — Network operating/switching report

1	2	3	4	5
Sub/overhead line	**Equipment**	**Operation/cause**	**Date**	**Time**
Scena 22 kV substation SF line	Line section SR 136/1 to EDN – SR line work order: (8010192135)	Schedule outage – Planned maintenance – Replace insulator		
	Breaker 22 [kV] SR1 – SR line	Breaker opened	2005/02/14	08:00:00
	Isolator 22 [kV] SR136/1 – SR line	Links opened	2005/02/14	08:05:00
	Breaker 22 [kV] SR1 – SR line	Breaker closed	2005/02/14	08:10:00
	Breaker 22 [kV] SR1 – SR line	Breaker opened	2005/02/14	10:50:00
	Isolator 22 [kV] SR136/1 – SR line	Links closed	2005/02/14	10:55:00
	Breaker 22 [kV] SR1 – SR line	Breaker closed	2005/02/14	11:00:00

B.3 Explanation of network operation

At 08:00 the main breaker opened and 1 200 customers were affected and 5 min later the links were opened at SR136/1. At 08:10 the main breaker was closed, but 300 customers beyond the SR136/1 links were still without supply. At 10:50 the main breaker opened and all 1 200 customers were without supply, 900 customers for the second time while the 300 from SR136/1 were not noticing this operation. At 10:55 the links were closed without affecting any customers. Only at 11:00 the main breaker was closed and supply was restored to all 1 200 customers.

B.4 Calculations of network interruption performance due to planned work

B.4.1 General

The measures below are calculated as monthly actual values assuming only the one incident of the example in B.3 for the particular month.

B.4.2 SAIFI calculation

In the operation described in B.3 a group of customers was affected differently from another group of customers. The 300 customers from SR136/1 to END experienced only one interruption, from 08:00 when the main breaker SR1 opened until the breaker was closed at 11:00. The other 900 customers on the network were interrupted twice, once from 08:00 to 08:10 and a second time from 10:50 to 11:00. If only this one event occurred for the month, the SAIFI for the network would be calculated as follows:

$$\text{SAIFI} = \frac{(900 \times 2) + (300 \times 1)}{1\ 200} = 1{,}75$$

Note that the denominator of the SAIFI calculation is equal to the total number of customers connected to the network. The numerator contains the summation of all the customers affected for a particular number of times. This is by assuming that the number of customers connected at the end of the month was equal to the number of customers connected at the beginning of the month.

On average, the customers on the network experienced 1,75 interruptions (some two interruptions and some only one interruption). The average is more towards two than one, because more customers experienced two interruptions.

Annex B
(continued)

When taking the pre-arranged event criteria into consideration, the interruption to the customers is seen as one interruption. The above is an example of a pre-arranged event. Ignoring the network operations under the same cause code (planned maintenance – replace insulators), it would result in treating the interruption as one sustained interruption from 08:00 to 11:00, affecting 1 200 customers.

The SAIFI will be calculated as follows:

$$\text{SAIFI} = \frac{(1\ 200 \times 1)}{1\ 200} = 1$$

From the above, it is clear that the interruptions created by isolating the work area from the rest of the network would not affect the SAIFI calculation negatively. However, the smallest number of customers needs to be affected during the pre-arranged outage from start to finish, as the numerator determines the weighting of a particular interruption on the overall network performance. If there was a current breaking device on section SR136/1, only 300 customers would have been affected. The SAIFI for the network would then be:

$$\text{SAIFI} = \frac{(300 \times 1)}{1\ 200} = 0{,}25$$

B.4.3 SAIDI calculation

From a duration point of view, 900 customers experienced two 10 min interruptions and 300 customers experienced a 3 h interruption. SAIDI for the network effectively calculates the average duration that the 1 200 customers on the network experienced. The measurement units are in hours, so 10 min equals 0,167 h in the following calculation.

$$\text{SAIDI} = \frac{(900 \times 0{,}167) + (300 \times 3) + (900 \times 0{,}167)}{1\ 200} = 1$$

On average the 1 200 customers were affected for 1 h. The bulk of the customers (900) experienced a 20 min outage (total duration) during the planned outage and the smaller group of customers experienced the long outage with a duration of 3 h. This explains why the average duration tends towards 20 min.

With the pre-arranged event criteria considered, the interruptions would be considered as a single interruption that lasted 3 h for the customers affected by the pre-arranged planned interruption (which are the 1 200 customers of the example above). The interruption time is taken from the first operation carried out under the same cause code till the last operation carried out under that cause code. SAIDI for the network would be calculated as follows:

$$\text{SAIDI} = \frac{(1\ 200 \times 3)}{1\ 200} = 3$$

From the example above, it can be seen that the isolation of the 300 customers before work started did not benefit the SAIDI figure. The smaller number of customers needs to be affected from the start of the interruption up to the end of the pre-arranged event. If there was a current breaking device on section SR136/1, only 300 customers would have been affected. The SAIDI for the network would then have been:

$$\text{SAIDI} = \frac{(300 \times 3)}{1\ 200} = 0{,}75$$

Annex B
(concluded)

B.4.4 CAIDI calculation

The CAIDI calculation calculates the average duration, which is equal to the average total duration divided by the average customer interruptions, as follows:

$$\text{CAIDI} = \frac{\text{SAIDI}}{\text{SAIFI}} = \frac{((900 \times 0{,}67) + (300 \times 3) + (900 \times 0{,}167))/1\ 200}{((900 \times 2) + (300 \times 1))/1\ 200}$$

$$\text{CAIDI} = \frac{(900 \times 0{,}167) + (300 \times 3) + (900 \times 0{,}167)}{(900 \times 2) + (300 \times 1)} = 0{,}57$$

Note that the denominator of SAIDI and SAIFI effectively becomes a division by 1, thus the CAIDI can be written as the numerator of SAIDI divided by the numerator of SAIFI. It thus took 0,57 h per interruption to restore power to each customer.

However, with the pre-arranged event criteria included, the average duration per interruption would be the duration of the interruption as the interruption in the example above and would be regarded as one interruption.

$$\text{CAIDI} = \frac{\text{SAIDI}}{\text{SAIFI}} = \frac{(1\ 200 \times 3)/1\ 200}{(1\ 200 \times 1)/1\ 200}$$

$$\text{CAIDI} = \frac{3\ 600}{1\ 200} = 3$$

Note that the 1 200 as the denominator is not the connected customers on the network, but the numerator of the SAIFI. Even if only the 300 customers were interrupted by using a current breaking device on section 136/1, the average duration of the interruption would still have been 3 h.

B.4.5 MSLI calculation

The MSLI is calculated in a similar manner as the SAIDI, but with the customer number figure being replaced with the MV network installed capacity figure. This time 4 MVA was affected for 10 min on two occasions and 1,5 MVA was affected for 3 h.

$$\text{MSLI} = \frac{(4 \times 0{,}167) + (1{,}5 \times 3) + (4 \times 0{,}167)}{5{,}5} = 1{,}06$$

This means that the total MV network installed capacity was without supply for an average duration of 1,06 h.

With the pre-arranged event criteria included in the calculation, this results in 5,5 MVA affected once during the pre-arranged event for the total duration of the event, thus resulting in an MSLI being calculated as follows:

$$\text{MSLI} = \frac{(5{,}5 \times 3)}{5{,}5} = 3$$

If a current breaking device was used to isolate section 136/1, only the 1,5 MVA would have been affected. This would have resulted in an MSLI as follows:

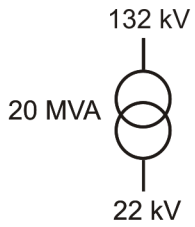
$$\text{MSLI} = \frac{(1{,}5 \times 3)}{5{,}5} = 0{,}82$$

The MSLI value is different from the SAIDI calculation because the distribution of MVA on the network is different from the distribution of customers on the network.

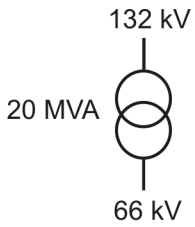
Annex C
(informative)

Definitions for transformer loss due to interruptions, for different winding configurations

C.1 Two-winding transformer



Use **20 MVA** as a loss.

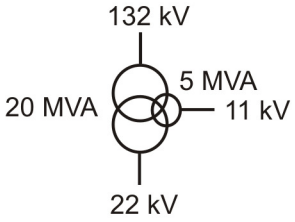


Drg.812a

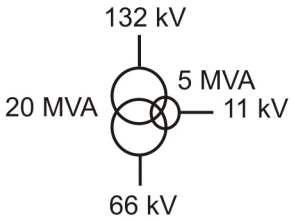
Coupling transformer no loss.

The coupling transformer is only traced if bulk customers were connected.

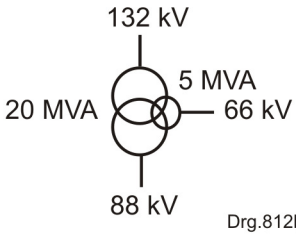
C.2 Three-winding transformer



Use **20 MVA** as a loss plus **5 MVA** if customers are connected.



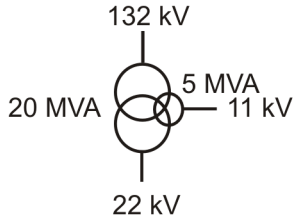
Use **5 MVA** as a loss if customers are connected.



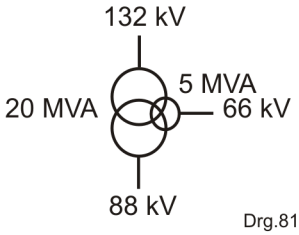
Drg.812b

Coupling transformer no loss.

C.3 HV power transformer



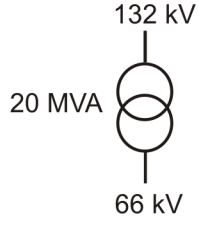
Use **20 MVA** as a loss plus **5 MVA** if customers are connected to tertiary.



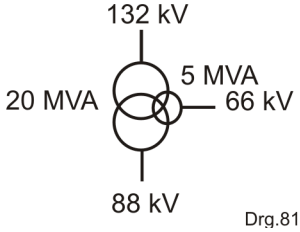
Drg.812c

Use **5 MVA** as a loss if customers are connected to tertiary.

C.4 Coupling transformer



Coupling transformer no loss.



Drg.812d

Coupling transformers no loss.

Bibliography

Standards

IEEE 1366, *Guide for electric power distribution reliability indices.* Available from World Wide Web: <www.ieee.org/web/standard>.

NRS 048-4, *Electricity supply – Quality of supply – Part 4: Application practices for licensees.*

NRS 048-8, *Electricity supply – Quality of supply – Part 8: Measurement and reporting of extra high voltage (EHV) and high voltage (HV) network interruption performance.*

NRS 082, *Recommended maintenance policy for electricity networks.*

SANS 1019, *Standard voltages, currents and insulation levels for electricity supply.*

SANS 1816, *Electricity supply – quality of supply: Power quality instruments.*

SANS 62271-100/IEC 62271-100, *High-voltage switchgear and controlgear – Part 100: Alternating-current circuit-breakers.*

Other publications

Cigré Technical Report TB261, *Power quality indices and objectives.* 2004. Available from World Wide Web: <www.e-cigre.org>.

Office of gas and electricity markets (ofgem), quality of service regulatory instructions and guidance. 2005. Available from World Wide Web: <www.ofgem.gov.uk>.

SABS – Standards Division

The objective of the SABS Standards Division is to develop, promote and maintain South African National Standards. This objective is incorporated in the Standards Act, 2008 (Act No. 8 of 2008).

Amendments and Revisions

South African National Standards are updated by amendment or revision. Users of South African National Standards should ensure that they possess the latest amendments or editions.

The SABS continuously strives to improve the quality of its products and services and would therefore be grateful if anyone finding an inaccuracy or ambiguity while using this standard would inform the secretary of the technical committee responsible, the identity of which can be found in the foreword.
Tel: +27 (0) 12 428 6666 Fax: +27 (0) 12 428 6928

The SABS offers an individual notification service, which ensures that subscribers automatically receive notification regarding amendments and revisions to South African National Standards.
Tel: +27 (0) 12 428 6883 Fax: +27 (0) 12 428 6928 E-mail: sales@sabs.co.za

Buying Standards

Contact the Sales Office for South African and international standards, which are available in both electronic and hardcopy format.
Tel: +27 (0) 12 428 6883 Fax: +27 (0) 12 428 6928 E-mail: sales@sabs.co.za
South African National Standards are also available online from the SABS website http://www.sabs.co.za

Information on Standards

The Standards Information Centre provides a wide range of standards-related information on both national and international standards, and is the official WTO/TBT enquiry point for South Africa. The Centre also offers an individual updating service called INFOPLUS, which ensures that subscribers automatically receive notification regarding amendments to, and revisions of, international standards.
Tel: +27 (0) 12 428 6666 Fax: +27 (0) 12 428 6928 E-mail: info@sabs.co.za

Copyright

Details and advice can be obtained from the Senior Manager.
Tel: +27 (0) 12 428 6666 Fax: +27 (0) 12 428 6928 E-mail: info@sabs.co.za