NRS 048-6:2019

Edition 2

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

NRS Association

N R S

This rationalized user specification is issued by
the Technical Governance Department, Eskom,
on behalf of the
User Group given in the foreword
and is not a standard as contemplated in the Standards Act, 1993 (Act No. 29 of 1993).

Table of changes

Change No.	Date	Text affected
2	May 2019	See the list of changes documented in the foreword in relation to Edition 2

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Foreword

This part of NRS 048 was developed to address the industry need for a national code of practice for the medium voltage (MV) network interruption performance (also referred to as continuity of supply) reporting by the distribution licensees in South Africa. The national code provides the measurement and reporting principles, definitions of the key performance index measures, the methodology for event data verification and quality assurance, reported statistics accuracy guidelines, and the requirements. This would assist the licensees in the correct interpretation and application of the network interruption performance statistical reporting to the National Energy Regulator of South Africa (NERSA).

The code provides the requirements for an interruption performance management system for either the manual or automatic capturing and recording of interruption event data. The interruption cause codes are provided for associating the supply interruptions with a common cause code hierarchy for the licensees. The relevant requirements for the disaggregation statistical business reporting, the annual regulatory reporting and benchmarking reporting by the licensees are provided.

Regulatory requirements, international standards and management 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 reporting to NERSA.

The changes and enhancements included in this second edition are:

a) revision of the forward and introduction to better address the *context* of network interruption performance;
b) expansion of the categories ;
c) the inclusion and clarification of categories of major events for internal licensee reporting;
d) inclusion of a generic application template;
e) the tracing principles and practical examples for MSLI and redundant transformers;
f) revision of the load shedding tracing and reporting;
g) theft and vandalism definitions and criteria for classifying events; and
h) roles and responsibilities of the licensee and NERSA.

Compliance with the requirements of this part of NRS 048 has been mandated by NERSA through inclusion of the first edition as a license condition to licensees in the electricity supply industry. It is anticipated that NERSA will also mandate this edition, as modified during its consultation processes, as a license condition in terms of the Electricity Regulation Act. Alternatively, this code may be included as a requirement under the Distribution Network Code.

General compliance by licensees to the code will be overseen by NERSA in terms of its licensing processes. It is recognized that present systems of the distribution licensees do not comply with the recommended requirements specified in this part of NRS 048 and therefore that the implementation of this part of NRS 048 may require additional resources and implementation work phased in over time by the distribution licensees in negotiation with NERSA.

It should be noted that NERSA may from time to time mandate alternative reporting requirements or clarifications on the provisions related to the application of this code. Readers are advised to confirm any such changes with NERSA or their responsible distribution licensee. It is anticipated that a formal structure will be identified or established by NERSA to review and make recommendations on clarifications and amendments required at short notice going forward for the clarification or amendment for the implementation of this code.

This part of NRS 048 was compiled by a working group appointed by the NRS Association. The working group membership included a wide range of stakeholders, including representatives of the South African Electricity Supply Industry, NERSA, Eskom Holdings, local and metropolitan municipalities. The working group at the time of publication of the second edition comprised the following members:

Foreword (concluded)

Chatterton B (Chairperson)	Eskom Distribution
Batohi V	eThekwini Municipality
Chitungo G	Eskom Distribution
Kgalema L	City Power Johannesburg Pty (Ltd)
Khumalo S	National Energy Regulator of South Africa
Kruger H	City of Cape Town
Kumalo L	Eskom Distribution
Mahuma N	Eskom Distribution
Kraal J	Eskom Distribution
Majola P	City of Ekurhuleni
Moloto M B	City Power Johannesburg Pty (Ltd)
Moloto P	City of Ekurhuleni
Nundlal V (Project Leader)	Eskom
Nunes N	Eskom Distribution
Ramagaga M	City Power Johannesburg Pty (Ltd)
Ratema D	National Energy Regulator of South Africa

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 practices for licensees.

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

Part 7: Application practices for customers.

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

Part 9: National Code of Practice: Load reduction practices, system restoration practices, and critical load and essential load requirements under system emergencies.

Annex A, B, C, and D is for information only.

Introduction

The distribution licensees in South Africa operate and maintain their medium voltage networks to ensure the reliability and availability of electricity for their customers. In order to measure, assess and audit the reliability and availability of electricity supply distributed by distribution licensees, the NERSA will require licensees to have consistent and robust measurement and reporting procedures. This will be important to reduce regulatory uncertainty and provide confidence in the interruption of supply related statistics 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 software programs, database and supervisory control and data acquisition (SCADA) systems that may be implemented to achieve the requirements by a licensee.

There is also a long term strategic benefit in that this part of NRS 048 will greatly assist the distribution licensees with the annual management and regulatory reporting of network interruption performance indices. The end objective is to cost effectively improve the reliability and availability of electricity supply to the customers in South Africa.

The NERSA needs to compare "apples with apples" for accurate and consistent interruption performance reporting and 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 exercised when network interruption performance benchmark exercises are being conducted to ensure a proper understanding of the context around the reported statistics. 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 base data, measurement, data collection and storage and reporting methodology 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.

Keywords

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

Contents

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) connected customers supply interruptions caused by events on the medium voltage (MV), high voltage (HV) and extra high voltage (EHV) systems. As such, this part of NRS 048:

a) provides the medium voltage interruption performance measurement and data collection requirements;

b) defines the performance indices for reporting and the calculation method of these indices in terms of the frequency and the duration of the customer experienced interruptions, installed power transformer capacity and bulk supply point;

NOTE The installed power transformer capacity refers to the licensee's asset. This is typically specified as the MVA rating on the name plate.

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

d) provides the treatment and reporting requirements of upstream intake supply points or transmission caused events;

e) specifies the treatment and reporting requirements of major events;

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

g) provides the data collection of interruption cause codes according to a standard hierarchy;

h) identifies the requirements for the disaggregation for annual regulatory and benchmarking;

i) specifies the data management and archiving, and system related changes; and

j) defines estimating the accuracy of reporting through event data assurance exercises.

NOTE 1 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 etc) 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.

NOTE 2 In some cases the network voltages of 33kV 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 these voltage networks (MV or HV) for consistent annual regulatory reporting purposes.

NOTE 3 The LV customers are aggregated to the MV supply point (e.g. the pole top mounted transformer).

NOTE 4 The reporting of MV and LV interruption performance is specifically separated from that of HV and EHV interruption performance reporting, because customer based interruption indices (e.g. SAIFI and SAIDI) consider each customer equally. This means the customers are counted as single individual customers irrespective of their size (i.e. a 100 MVA customer and a rural customer are counted the same).

NOTE 5 HV and EHV system interruption performance indices and reporting are addressed in the NRS 048-8 specification.

NOTE 6 The network interruption performance indices used for regulatory purposes may 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 the individual customers are monitored and reported.

1.2 This part of NRS 048 is predominantly focused on the primary plant performance, but the key secondary plant (or control plant) related matters that impact on the primary plant performance are also considered.

1.3 This part of NRS 048 provides a high level internal quality assurance processes, data completeness assurance 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.

1.4 The medium voltage network interruption performance 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, and an internal assurance process that is independent to ensure the completeness and accuracy of the procedures.

2. Normative references

The following documents contain provisions which, through reference in this text, constitute provisions of this part of NRS 048. All documents are subject to revision and, since any reference to a document is deemed to be a reference to the latest edition of that document, parties to agreements based on this part of NRS 048 are encouraged to take steps to ensure the use of the most recent editions of the documents listed below.

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

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 048-9, *Electricity supply – Quality of supply – Part 9: Code of Practice – Load reduction practises, system restoration practises and critical load and essential load requirements under power system emergencies*

NRS 047, *Electricity Supply – Quality of service and reporting guidelines*

3. Terms, definitions and abbreviations

For the purposes of this national code, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

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 [NRS 000].

bulk supply point: the point to be used as the physical demarcation point between the licensee and the customer as defined in the supply agreement.

NOTE The licensee is to ensure the contracted notified maximum demand values are up to date in the relevant system.

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 that has entered into an electricity supply agreement with a licensee [NRS 000].

NOTE 1 This also includes temporarily disconnected customers.

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

customer connection count: This is the number of customers connected to the network of the licensee.

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.

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 $< U_n \leq$ 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 1 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 interruption is counted as a new interruption and assessed separately.

NOTE 2 This is for KPI reporting purposes based on interruption reported. The operational and resource for the event measurement management is separate.

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

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

IPP: Independent Power Producer (IPP) means any undertaking by any person or entity, in which the government of South Africa does not hold a controlling ownership interest (whether direct or indirect), of new generation capacity at a generation facility following a determination made by the Minister in terms of section 34(1) of the Act;

NOTE An IPP is an independent power producer who is not a public entity, but owns facilities to generate electricity for sale to licensees and end users. The IPP must have a generation licence granted by NERSA and a contract with the licensee or end user it is supplying electricity to.

installed capacity of a power transformer: the nameplate rating indicated either in KVA or MVA.

intake supply point: the point to be used as the physical demarcation point between the supplier and the distribution licensee as defined in the supply agreement.

NOTE The supplier could be another distribution licensee, or a transmission licensee or a licensed IPP.

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

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

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

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 (ME): 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. Refer to 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 **$1\ kV \leq U_n < 44\ kV$**
[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): 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.

reliability: a measurement of the continuity of supply [RSA Distribution Code definitions].

NOTE 1 This is to quantify how often the electrical supply was interrupted in a predefined period of time.

For the purposes of this specification, this will be defined as the frequency (or number of times) that a supply interruption affects a customer, or a power transformer, or a defined point of supply.

NOTE 2 An example of this is the System Average Interruption Frequency Index (SAIFI) to report the average number of sustained interruptions occurring over a predefined period.

reporting period: time period for reporting the network interruption performance negotiated between the licensee and NERSA.

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

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.

unavailability of supply: the average duration of an interruption of supply experienced by the customer (how long was the customer or transformer switched off);

NOTE For the purposes of this specification, the unavailability is defined as the average duration of time that a supply interruption was experienced (i.e. the supply was off)) by a customer or a power transformer or supply point on the distribution network. An example of such a measure would be the Medium Voltage Supply Loss Index (MSLI).

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
DPE: Department of Public Enterprises
IEEE: Institute of Electrical and Electronic Engineers
MAIFI: Momentary average interruption frequency index
MSLI: MV supply loss index
NERSA: National Energy Regulator of South Africa
PTO: permission to operate
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

4. Recommended requirements for network interruption performance reporting

4.1 Capturing of network events

4.1.1 A licensee may choose to implement automatic (system generated) or manual (user input) recording of events. The normal procedures and where appropriate, the system functionality for capturing of network events should allow for the clause 4.1.1.1 to 4.1.1.8 to apply.

4.1.1.1 Facilitation of the structured capture of all interruption of supply events (including telemetered and non-telemetered events that occur).

4.1.1.2 Capturing the correct individual customer restoration of supply times during fault finding and network operating (switching). This should allow for the manual entering of all switching or operating actions during the customer supply restoration process.

4.1.1.3 Interruption cause code hierarchy capturing in accordance with the requirements recommended in section 8.

4.1.1.4 A data connectivity model from the HV system to the LV customers connected via the MV/LV transformers. The model maps the customers connected to the transformers in the field to the information used by the system for calculating and reporting the network interruption performance statistics. The data connectivity model should be maintained and updated regularly by the licensee.

The recommended end state connectivity model completeness and accuracy levels are:

a) in the case of HV customers : > 99% of all HV customers linked;
b) in the case of MV customers : > 95% of all MV customers linked; and
c) in the case of LV customers connected to MV/LV transformers:> 75% of all LV customers linked.

The completeness and accuracy levels should be negotiated between the licensee and NERSA.

NOTE 1 The percentages above are based on the end state status. It is recognized that licensees might not be at the current completeness and accuracy levels and will require resources and time to reach the required levels of completeness.

NOTE 2 The accuracy requirements are the customer linked to the correct MV/LV power transformer on a network per geographic area.

NOTE 3 The licensees may need to justify to NERSA, levels less than the above recommended levels based on their particular operating environment, data accuracy levels, business circumstances and resource constraints.

4.1.1.5 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.

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

4.1.1.6 Allow for the captured event data to be merged and filtered into logical formats for analysis or formats specified by the licensee based on their specific reporting method.

4.1.1.7 Provide diagnostic procedures to be implemented to identify the missing or incorrect plant location and customer data.

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

4.2 Data validation

The normal procedures and where appropriate, the system functionality for capturing of network events should allow for the following:

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

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

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

d) the downstream customer information to be updated and the overall network interruption performance indices to be recalculated accordingly; and

e) an audit trail to track the persons responsible for entering and changing the data, including the date and time and the reasons for the changes.

4.3 Network event and statistical reporting

4.3.1 The following business information should be reported on by the licensee:

a) geographical reporting hierarchy (e.g. total licensee area, operating depots / districts or areas, substation and per individual network);

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

c) reporting per interruption type category;

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

e) The performance trend per geographical hierarchy and time period (e.g. the 12 month performance of a specific district or the 3 year performance of the total licensee).

4.3.2 The following network event and asset information should be reported on by the licensee:

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 per switching operation;
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 interruption statistical information should be reported on by the licensee:

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 entry point through user selection of the customer from a list of all connected customers;

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

f) the breakdown reports for the interruption categories;

g) the number of momentary interruptions; and

h) the number of sustained interruptions.

5. Interruption categories for reporting

5.1 General

In order to facilitate the consistent and common data reporting requirements for network interruption performance, categories and associated sub-categories of sustained and momentary interruptions

are defined below. An interruption is not defined in terms of voltage magnitude 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 should be used to assist in the correct interruption assessment.

NOTE When interruption performance data is being provided, the exclusion of any categories of interruption should 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 annual regulatory reporting requirements.

5.2 Interruption categories

5.2.1 Categories and codes

The categories and sub-categories for the classification of interruption types are listed below. It is important for the licensee to use these codes as the foundation for their own enhanced reporting.

5.2.2 Unplanned interruption (“U”)

The following abbreviations apply:

a) network event [“UN”];
b) emergency [“UE”];
c) major event [“UME”];
d) third party [“UTP”];
e) IPP caused [“UIPP”] and
f) illegal connections [“UIC”].

NOTE The illegal connection is not a customer of the licensee.

5.2.3 Planned interruption (“P”)

The following abbreviations apply:

a) network [“PN”];
b) IPP requested [“PIPP”]; and
c) security [“PS”].

NOTE This is the work to implement theft and vandalism mitigation on the licensee’s network and plant.

5.2.4 Customer related (“C”)

The following abbreviations apply:

a) customer caused [“CC”]; and
b) customer requested [“CR”].

5.2.5 Intake supply related (“IS”)

The following abbreviations apply:

a) unplanned [“ISU”];
b) planned [“ISP”]; and
c) load shedding [“ISL”].

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

NOTE 2 The national capacity load shedding related interruptions are reported separately as these interruptions are not related to normal operations for network interruption performance reporting.

5.3 Application of unplanned interruption category

5.3.1 Network event

An unplanned interruption should be categorized as “Network Event” where any one of the following condition applies:

a) the interruption is due to network fault conditions (transient or permanent), or to protection mal-operation, 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, or in the relevant customer contract) was provided to the customer.

NOTE Currently NRS 047 specifies a 48 hour notification time for planned interruptions to customers and should be consulted on the latest requirements.

5.3.2 Emergency

An unplanned interruption should be categorized as an “Emergency” where it can specifically be shown that a condition existed that posed an immediate and direct threat to the safety and wellbeing of animals and humans, or could possibly have caused severe damage to the plant of the 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, should 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 should 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 and compliance direction for the industry.

NOTE 1 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 should 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 constraint and then only if it fits the criterion specified below; otherwise it would be treated as an unplanned interruption.

NOTE 2 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.

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

An unplanned interruption should 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: once-off non-weather abnormal events (for annual reporting and year on year licensee performance tracking)

An unplanned interruption should be categorized as a "major event" for once-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 hours or longer;

b) more than 10% installed MVA transformer base (Either HV or MV voltage supplied base and not accumulative) of the distribution licensee is without supply and the affected transformers are without supply for 12 hours or longer; and

   NOTE The accumulative transformer bases stipulated within the criteria are based on the appropriate geographical boundaries established by a license's operating areas that are approved by NERSA.

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 should not be direct contributory factors to the occurrence of the major event and the licensee should take all appropriate steps within its power, to restore the supply within legal and safety obligations~~,~~ 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 operating units.

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

An unplanned interruption should 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) a minimum of 5% (based on installed transformer capacity) is affected as a result of a severe weather related event; and

   NOTE The criteria apply to HV or MV installed base and must be quantified independently and not cumulatively.

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 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 a transparent process with supporting documentation.

5.3.4 Separate reporting (for internal licensee reporting)

Separate reporting does not imply automatic exclusion or exemption by NERSA. These are events caused by external third party and other licensee caused interruptions. This criterion is to include interruptions caused by a third party (i.e. customer, public, other supply licensees) and intake suppliers (i.e. losing supply due to interruption on an upstream distribution licensee's network).

5.3.4.1 D.1. Interruption caused by other distribution licensee

When the intake point supplied by another distribution licensee is not available to supply the network or end customer.

5.3.4.2 D.2. Interruption caused by independent power producers (IPPs)

When an IPP causes an interruption or requests an outage, thus affecting the distribution licensee.

5.3.4.3 D.3. Staff, contractors, public or animals safety at risk

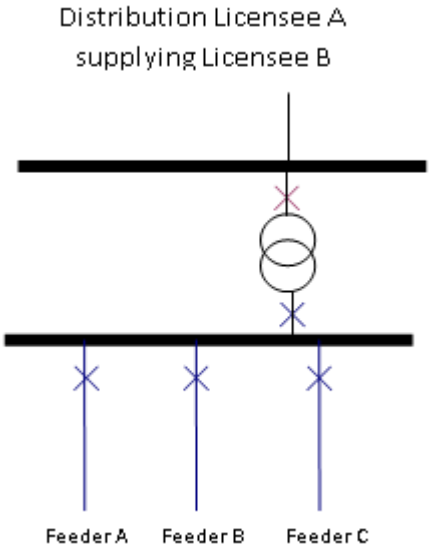
When the distribution licensee's personnel or public's personal safety are at risk in an attempt to restore supply to a network or end customer. The same condition would apply if a forced interruption is required to ensure the safety of the distribution licensee's personnel or public.

5.3.4.4 D.4. External third party caused

When an interruption is caused by an external third party (i.e. public, direct end customer supplied by the distribution licensee or other external public utility services (i.e. Telkom, Road Works, SANRAL, Randwater, JRA etc.).

5.3.4.5 D.5. Interruption caused by other distribution licensee (but not as a result of its intake supply points)

When another distribution licensee is the direct cause for an interruption, but their intake points to the distribution licensee are still available.



Scenario in D.5.

- Licensee A is supplying Licensee B's substation
- Licensee A, while working on their network causes a fault on "Feeder C", which is the responsibility of Licensee B.
- Licensee A's supply point to Licensee B's substation is still healthy, yet it directly contributed to the interruption

Figure 1 — Example of a network scenario for criterion D.5.

5.3.4.6 Lower level geographic reporting (for internal licensee reporting)

This criterion is introduced to assist the distribution licensee in quantifying the impact of a "major event", but on a local distribution licensee's technical operation area. An event can take place, which can have catastrophic impact on a localized area supplied by the distribution licensee, but yet it does not meet the conditions as defined in criterion B or C, due to the impact of the interruption being quantified against the total customer and installed MVA base of the distribution licensee and not against the localized area.

The introduction of this criterion is to assist the distribution licensee in managing and quantifying the impact on a localized technical area for internal reporting. The following conditions are proposed:

a) more than 10% of the installed customer base of the demarcated technical service operating area is without supply for 12 hours or longer; or

b) more than 10% of the supply load (installed MVA transformer base + dedicated bulk loads) of the demarcated technical service operating area is affected for a period of 12 hours or longer. The criteria apply to HV or MV installed base and must be quantified independently and not cumulatively.

Take note that this criterion is not limited to a specific cause as per criterion B and C, but is focused more on the impact to the local network.

5.3.5 External third party

An unplanned interruption should be categorized as an “external 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 plan to report 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

5.4.2.1 A planned interruption should be categorized as “pre-arranged” when 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 should have been notified of the planned interruption in accordance with the minimum period prescribed in NRS 047 or as otherwise contractually agreed upon.

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

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

5.4.2.2 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 should 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 should 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 to provide a measure of the distribution licensee’s quality of service provided.

5.4.3 Major event

A planned interruption should be categorized as a “major event” where any one of the criteria specified in section 5.3.3 applies. 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 should 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 should 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 should 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 should 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 should inform the affected distribution licensee of the planned

interruption at least seven (7) working days ahead of time, in writing, and direct the information to the responsible person to enable the affected customer (licensee) to inform their own customers.

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5.6.3 Load shedding

An intake supply related interruption should 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.

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 Load reduction and load shedding events

Load reduction events (customer voluntary and involuntary) 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 should not be classified as interruptions, but should be assessed and reported separately.

NOTE NRS 048-2 currently provides the requirements of voluntary and involuntary load reduction events. This clause may change subject to the publication of the South African Grid Code.

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 seconds, such an event is defined as a single phasing event by the distribution licensee. This is also loosely referred to as “single phasing” and should 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. Network interruption performance indices

6.1 Introduction

The following network interruption performance indices provide measures to quantify the reliability and unavailability of supply:

a) unavailability of supply – the average duration of an interruption of supply experienced by the customer (how long was the customer or transformer was switched off);

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 requirements);

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

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

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 minutes 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 section 4.3.

NOTE The 5 minutes 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 minutes) 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 principle and operational constraints of applying re-interruptions should be negotiated between the licensee and NERSA.

The subsequent interruptions due to fault finding or network operating that are associated with the original network interruption should be referred to as re-interruptions. This is includes all work and operating carried out on a network to restore the supply that is relevant to the original fault that occurred on the network. 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 should 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 or the nearest operating point.

A simplistic rule-of-thumb is provided below to promote the understanding on the re-interruption concept:

a) breaker trip – close – trip < 3 hours: re-interruption; and

b) breaker trip – close – trip ≥ 3 hours: 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 hour for all the connected customers, the whole network has supply restored for 30 minutes (assuming no step restoration), the whole network has a further loss of supply for 30 minutes, 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 hours.

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.

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

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 may 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.

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

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

or expressed as:

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

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:

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

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:

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

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)

6.2.8.1 Definition

The MSLI of a network indicates the average transformer and bulk supply point loss duration due to sustained interruptions. It is a measure of the MV supply points' unavailability (MV transformer and Customer Bulk point (CT/VT unit) unavailability) and is expressed in hours per month.

Mathematically MSLI would be expressed as:

$$\text{MSLI} = \frac{\Sigma \text{ MVA.Hours.lost per month}}{\Sigma \text{ Installed MV MVA base} + \Sigma \text{ Customer Bulk MV MVA base (Contracted)}} \quad (8)$$

MVA base to be used within the above formula:

a) installed MV MVA base – Summated MVA of the affected transformers' capacity;

b) customer bulk point base – Summated MVA of the individual contracted MVA (notified maximum demand. If there is no bulk customer point affected, then MVA is zero;

c) in case of ring networks, the affected MVA is based on the configuration of the network at the time of the interruption; and

d) the licensee to consider the IPPs declared supply demand (MVA) and duration to be included, but only if declared and specified within the contract between the IPP and the distribution licensee.

NOTE The MSLI and HSLI measures are not designed to be interpreted as a summated total measure, but rather as separate measures providing information about the unavailability of the different types of networks based on the supply voltage and installed base.

6.2.8.2 Application 33kV networks

The application of the 33kV networks by licensee (i.e. network is distributed via a 33kV voltage or voltage is transformed down to 33kV level directly to customer (busbar)) is dependent on the operational requirements of the licensee. The 33kV networks could be classified as either Medium Voltage or High Voltage by the licensee. Refer to figure 1 and 2 below for the two examples.

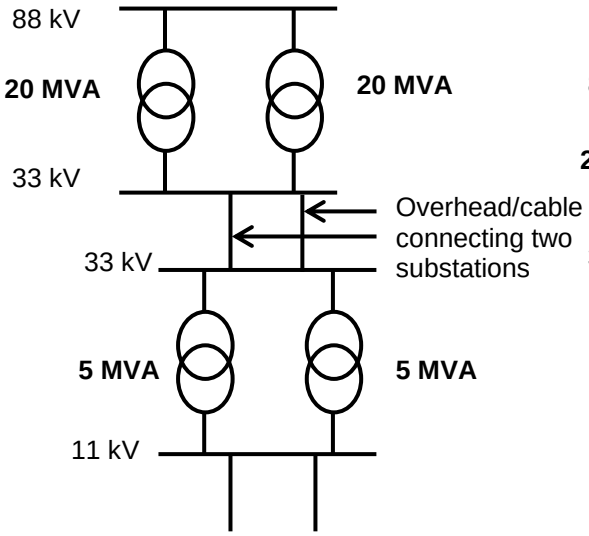


Figure 2 — Example of a 33 kV network, where the 33kV network is used as a distribution voltage. In this case the 33kV would be classified as a high voltage instead of a medium voltage

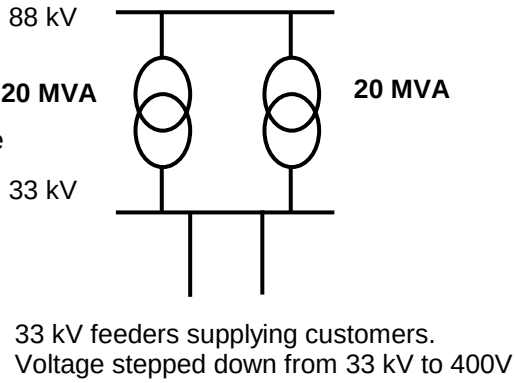


Figure 3 — Example of a 33 kV network, where the 33kV network is reticulated to the customers. In this case the 33kV would be classified as a medium voltage instead of a high voltage

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 could be reported either separately or together.

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 minutes). 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 should 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 should be provided in any report submissions. Otherwise, the licensee should 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 should 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:

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

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).

7. Network event data auditing and validation

7.1 Network events to be validated

All the following network events should 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 (control) 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 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 should be the earlier date and time at which either of the following occur:

a) the time of the first report by a customer or third party ;

b) the time the licensee became aware of the event based on the interrogation of the licensee's plant and equipment; or

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

7.2.2 Interruption start times

The interruption of supply start time should 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;

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

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

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 should be applied:

a) supply has been restored to all the affected customers for 3 hours and longer. An interruption that occurs after 3 hours or longer after the previous interruption, should 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 should 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 should 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 should be made available to be audited on request by the customer or the NERSA; and

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 should be made available to be audited on request by the customer or the NERSA.

7.4 Permission to operate (PTO)

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

7.5 Number of customers affected

The number of customers affected should 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 should 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 should 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 should 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 should 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 should 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 determine 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 should 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 should be recorded where supply to the network was affected. The user should 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, should 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 should accurately determine these durations by analysing the effect of the switching times of the plant on the transformers, for manual tracing.

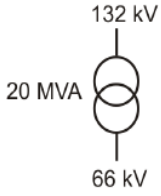
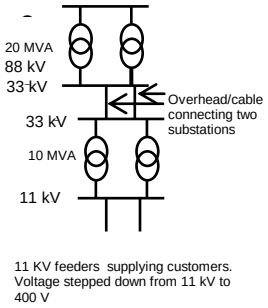
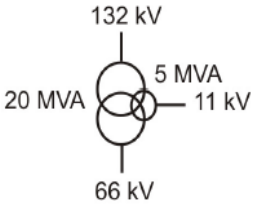
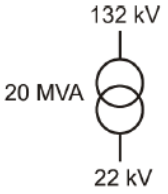
This process of analysis can be conducted by reviewing the on and off times of all the events and customers and the sequence of the times on the operating sheets and SCADA.
Timeline analysis assists the user in determining the correct off and on times to which the plant and customers have been subjected.

7.6.7 MSLI tracing methodology principle

There are transformers, which depending on the network configuration can either be included or excluded from the SLI measure. The table below defines the various configurations i.e. transformer categories and the proposed business rules to include or exclude from the KPI calculations.

7.6.7.1 Transformer category

Table 1 — Transformer category and their inclusion or exclusion in the KPI calculation

1	2	3	4
Transformer category	**Definition**	**Include / exclude from KPI**	**Diagram**
Auxiliary transformer (AT)	Refers to any transformer that has been installed and supplied from a supply transformer with the purposes of supplying auxiliary equipment or supply points	Excluded	Not applicable
Coupling transformer (CT)	Step down transformer not supplying customers directly, but to distribute and transform to a lower voltage for further downstream networks before supplying the end customers i.e. refers to transformer where the primary (incoming) and secondary (outgoing) voltages are of the same voltage group (i.e.44 kV ≤ Un ≤ 220 kV or 1 kV ≤ Un < 44 kV).	Excluded	
Coupling transformer (CT) – For 33kV	If 33kV is used to distribute voltage and not reticulate to the customers, then the transformer capacities is to be classified as coupling transformer load example the 20MVA transformers (in the illustrated figure) will be classified as a coupling load (CT), while the 10MVA transformers will be classified as Supply Loss(L)	Excluded	
Tertiary winding transformer loss (TL)	***Tertiary winding transformers ONLY*** Refers to any transformer where the primary (incoming) and secondary (outgoing) voltages are of the same voltage group (i.e.44 kV ≤ Un ≤ 220 kV or 1 kV ≤ Un < 33 kV) with a tertiary winding of a different voltage group, where the customers are supplied from.	Included (Only if tertiary winding is supplying customers else same as Coupling (C)	
Supply loss (L)	Refers to any transformer, where the primary and secondary winding are of different voltage group i.e. primary voltage group is within the range 44 kV ≤ Un ≤ 220 kV and the secondary is within the range Un < 44 kV NOTE This is the “loss” (bulk or transformer affected) due to an interruption.	Included	

7.6.7.2 Redundant transformers

Redundancy is only to be used when a supply point (transformer or bulk point) is interrupted, but does not affect the supply to the end customer. By ring fencing the network interruption transformer supply loss which has been flagged as “redundancy”, the licensee can quantify the MSLI savings MVA hrs that would not be included within the indices calculation where MVA is the installed capacity) due to supply contingencies, network operating and configuration optimization.

The flagging of network losses as redundancy can also encourage the optimizing of planned maintenance outages. The following are the examples of outage optimization (savings would be on the HSLI only)

a) when scheduled maintenance is conducted simultaneously on either side of the transformer i.ie HV and MV, the MV side would be included in MSLI as it affects the end customer, but the HV side (transformer) would be flagged as redundancy and therefore excluded from the HSLI; and

b) when a scheduled maintenance is conducted on an HV side of the transformer, but does not affect the supply to the MV network i.e. the end customer.

NOTE Savings refers to network interruption losses which refers to the installed MVA, that if meet specific criterion, will not be included into the indices' calculation, and hence would be deemed as a saving.

Table 2 — Types of redundant transformer categories and their definition

1	2	3
Transformer category	**Definition**	**Include / exclude from KPI**
Redundancy Transformer (RT)	Refers to any transformer, which is surplus to the normal network configuration or availability at the time of the interruption, and therefore the customer still had supply provided by the licensee.	Excluded
Contingency Redundant Transformer (temporary) (CR)	This category refers to any transformer that is used as an interim arrangement (e.g. mobile power transformer unit)	Excluded
Customer agreement (CA)	Refers to a special situation where there is a written agreement between the customer and the licensee that is mutually agreed on the restoration time of the power transformer or bulk supply of the licensee.	Excluded

7.6.8 Tracing of national load shedding

The principle objective of this proposal is to compile a process to enable a Distribution licensee to ring fence "Eskom National Control" and "Under-frequency" load shedding events, thus enabling the licensee to report the impact of national load shedding events separately from the overall network interruption performance. The process will enable a Distribution licensee to compile reports to the Regulator NERSA, which would include the network interruption performance indices with the exclusion and inclusion of national load shedding impact losses.

A standardized methodology will ensure consistency within the compiling and reporting of load shedding caused events.

7.6.8.1 Load shedding definition

7.6.8.1.1 There are numerous types of load shedding scenarios, however only specific type of load shedding scenarios are to be considered for ring fencing and reporting separately.

7.6.8.1.2 The following should be reported as "national load shedding" for network interruption performance indices:

a) manual load shedding or curtailment instructed by Eskom's National System Operator in response to a national supply-demand constraint – (i) where it is caused by a generation or import constraint, (ii) including where such shedding/curtailment is not strictly rotational – i.e. if a load shedding event lasts less than 2 hours such load shedding will be reported; and

b) all under-frequency load shedding schemes.

7.6.8.1.3 The following should not be reported as Eskom national load shedding or un-served energy for network interruption performance indices:

a) load curtailment, which refers to the load reduction obtained from customers who are able and willing to curtail usage of power. These loads are to be curtailed within 1 hour of the instruction being issued by Eskom National Control (via the Eskom Distributor Network Management Centres);

b) energy not served due to network constraints, thus resulting in internal load shedding with the Distribution licensee's network;

c) schemes such as ripple-control; and

d) internal load shedding or load swinging events, as a result of network design constraints, are to be classified as a supply interruption.

7.6.8.2 Load shedding business rules for reporting

There are several requirements to ensure that there is consistency within the capturing of load shedding caused events. By complying to these requirements, it will ensure a higher confidence level within the reported indices and the impact of the load shedding caused events.

7.6.8.2.1 Timelines

Distribution licensee networks switched off during load shedding, manually or via Telecontrol shall be restored within one hour after Eskom National Control has declared the national grid stable. All network losses incurred after the recommended 1 hour should be categorized and captured as a fault.

Refer to Figure 4 below.

a) Milestone 1: This is the time Eskom National Control instructs Distribution licensees to load shed;
b) Milestone 2: This is the time Eskom National Control informs the end of load shedding. Distribution licensees can restore networks; and

c) Milestone 3: This is the time the Distribution licensee's networks are fully restored back to normal. The recommended duration is depended on the licensee's operating constraints i.e.

i) Have no telecommunication for remote operations,
ii) Failure of remote operations,
iii) Sequential switching to reduce risk of overload trips due to inrush currents, and
iv) Logistics in accessing the substations for manual switching

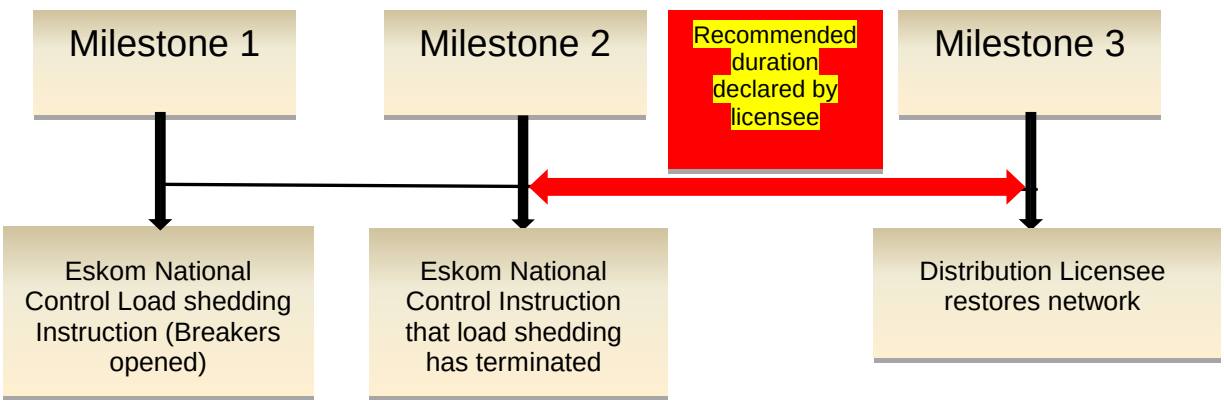


Figure 4 — Timeline of load shedding event capturing process (Only interruptions within the recommended milestones are ring fenced and included within the load shedding caused events)

7.6.8.2.2 Flagging of load shedding events

The flagging of load shedding events are dependent on the distribution licensee's fault capturing system capabilities. It is up to the distribution licensee to establish a process to uniquely flag and ring fence events that have impacted the network as a result of national load shedding.

7.6.8.2.3 Concurrent maintenance with load shedding events

A Distribution licensee can apply opportunist maintenance i.e. the Distribution licensee can proactively schedule for maintenance to run concurrent with the load shedding event. However if the maintenance outage duration exceeds the load shedding event's duration, then the exceeded duration shall be categorized as a planned outage and not ring fenced as part of the load shedding outage.

The customer should be notified within the required planned interruption communication time.

7.6.8.2.4 Evidence of load shedding events

A Distribution licensee shall require evidence to confirm the occurrence of national load shedding events.

7.6.9 Criteria to flag and report validated theft events impacting the licensees network interruption performance

7.6.9.1 Theft caused criteria

An interruption incurred as a result of theft or vandalism to the licensee's network infrastructure, is to be flagged (ring fenced) as a theft event if;

a) the network/s affected is within the same network center boundary; and

b) the network losses incurred as a result meet one of following parameters:

i) The event's customer interruption duration (CID – SAIDI impact) exceeds 3 times the average CID unplanned event by three times over the past three years (same network operating center) i.e. Event CID > 3 x Average unplanned events CID over the past three year cycle.

Unique number of customers affected exceeds the average unique customers of unplanned events within the same technical operating center over the same three year cycle

ii) The event's customer interruption (CI – SAIFI impact) exceeds the average CI unplanned event by three times over the past three years (same network operating center) i.e. Event CI > 3 x Average unplanned events CID over the past three year cycle.

Unique number of customers affected exceeds the average unique customers of unplanned events within the same technical operating center over the same three year cycle

iii) The event's High voltage MVAhrs lost (HSLI impact) exceeds the average HV MVAhrs unplanned event by three times over the past three years (same network operating center) i.e. Event HV MVAhrs > 3 x Average HV MVAhrs unplanned events over the past three year cycle.

iv) The event's Medium voltage MVAhrs lost (MSLI impact) exceeds the average MVAhrs unplanned event by three times over the past three years (same network operating center) i.e. Event MV MVAhrs > 3 x Average MV MVAhrs unplanned events over the past three year cycle.

NOTE 1 The average CID, CI and MVAhrs per theft and vandalism events for the affected network centre to be provided by the licensee in the case of the distribution licensee motivating for exclusion. When calculating the average, previously excluded events should be included in the calculations. For the event being evaluated, its related losses should not be included within the calculation when determining the thresholds.

NOTE 2 The Distribution Licensee is accountable to have a theft mitigation strategy in place. Evidence of such initiatives is to be submitted by the licensee during its application to assist in the review and evaluation process of the application.

7.6.9.3 Theft caused criteria reoccurrence of theft event within same network

The criteria as defined within section 2, also ensures that although a specific event initially meets the defined criteria for a specific defined date, it does not mean a similar event would meet the criteria a year later. The reason being that the average CID would increase hence the thresholds would also increase. Effectively it means that reoccurrence of a theft caused interruption within the same network without any intervention form the distribution licensee to mitigate its impact will result in the averages increasing and the event not meeting the criteria.

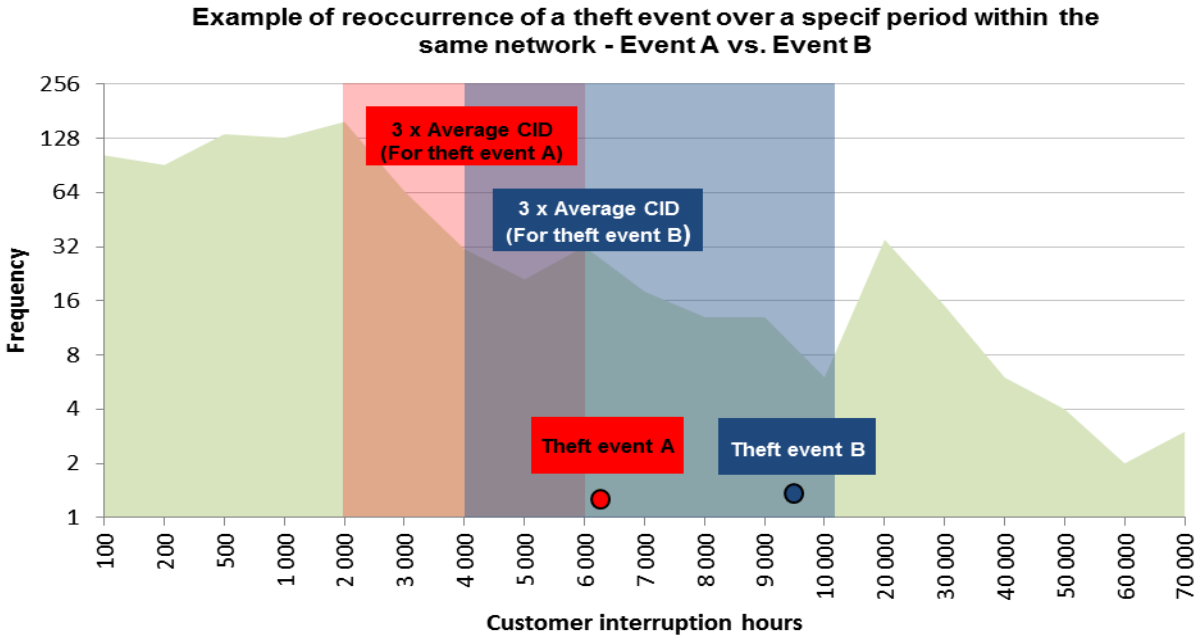


Figure 5 — Example of a theft event

Theft event A and theft event B occurred within the same network over two different time periods. Theft event A meets criteria as defined in section 2. Theft event B does not meet criteria due to the increase in the average CID.

7.6.9.4 Theft caused applying theft caused criteria

A theft caused event (theft event A) was selected to evaluate if it meets the criteria defined in section 2.

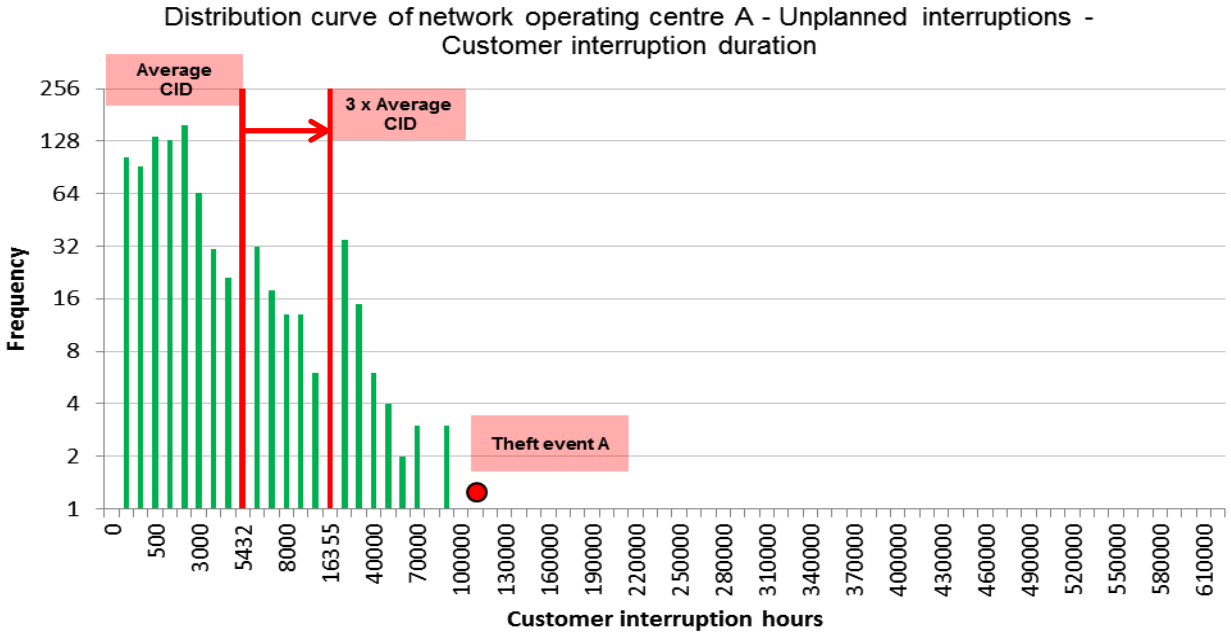


Figure 6 - Example of assessing theft event based on proposed methodology

Figure 2 represents the distribution curve of all unplanned interruptions for “Network Operation Centre A” over a three year period.
Theft event A was selected.
“Customer interruption duration” of the selected event was evaluated against the criteria i.e. 3 x average customer interruption duration for unplanned events.
The average CID and the 3x average CID are indicated in figure 2.
Number of theft caused events over the selected period is 33.
Total number of unplanned events over the selected period is 891.

Evaluate “Theft event A” against criteria defined in section 2:

Same technical operating area – *Meet criteria* (Defined in section 2)

CID of selected theft caused event > 3x average CID of unplanned events – *Meets criteria* (Figure 2)

Unique customers affected for the selected theft event > average unique customers affected for unplanned events. Selected “theft event A” affected 12 624 customers. Average unique number of customers for unplanned events is 1 238 – *Meets criteria* (Defined in section 2).

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) given below, 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

The primary cause codes are categorized as follows:

a) equipment failure;
b) planned work;
c) operational causes;
d) intake supply;
e) vegetation;
f) fire;
g) natural events;
h) insulation pollution;
i) animals;
j) customer;
k) theft and vandalism;
l) third party;
m) unknown; and
n) other.

8.2.1 Equipment failure

The following should 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, other related secondary plant etc.);
g) failure of the protection system (e.g. relay failure, DC failure, etc);
h) failure of the load reduction systems ; and
i) other failures.

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;
d) licensee's staff or licensee's contractor causing damage to a licensee's network and equipment;
e) emergency;
f) overload;

8.2.4 Intake supply

The loss of supply at a licensee intake supply point caused by the supplier licensee.

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 should 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, tsunami, floods, tornadoes etc).

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 Animals

The following apply:

a) wild
b) domestic
c) birds (physical contact / bird streamers / pollution, etc.); and

d) other.

8.2.10 Customer

The supply interruptions caused by customer equipment failure.

8.2.11 Theft and vandalism

The following apply:

a) theft; and
b) vandalism

Refer to section 7.6.9.

8.2.12 Third party

An external party conducting activities not related to a licensee's business operation causing damage to a licensee's network and equipment.

NOTE If a tree outside a servitude of a line is cut down 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 should provide a brief description of each interruption assigned to the unknown category.

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 should provide a brief definition and description of each interruption assigned to the other category. The licensee should ensure the supply interruptions are investigated before assigning to the other cause code category.

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 should 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; and
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 should 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; and
d) a comparison of the “before” and “after” impact of the system change 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 important for annual regulatory reporting. The information below will apply once the systems are functional and there is confidence in the reported measures.

The distribution licensee should 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 should comply with the accuracy levels for the number of customers interrupted and the duration of interruptions of supply.

The distribution licensee should 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 should 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 recommended that the licensee should conduct annual self-audits.

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 risk 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 should 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 should 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 should 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 should 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 should be provided;

c) an explanation as to why the event was not under the licensee's direct control, taking into account safety and legal obligations 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;

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

i) Refer to Annex A for the reporting template.

10.2 Requirements for annual power quality reporting

10.2.1 Annual reporting

Annual reporting to NERSA should be on a prescribed basis for all the licensees. NERSA to advise the licensees of the requirement.

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 should be calculated as the customer weighted average of the relevant districts or areas.

10.2.2.3 Interruption performance measures

The licensee should 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 should 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 should 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 should be excluded from interruption performance indices, but the relevant information should be reported separately:

a) customer category interruptions;
b) intake supply related interruptions;
c) national load shedding events; and
d) separate reporting events.

10.2.3 Customer connection count numbers reporting

The distribution licensee should 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 should 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 should 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);and
c) aerial bundled conductor (ABC) 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, should be estimated where precise information is unavailable.

10.2.5 Sum of installed transformer capacity

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

a) the total number of MV/LV transformers; and
b) the sum of transformer capacity, in megavolt amperes, for MV and LV (transformer nameplate information should be used).

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

10.2.6 Areas of distribution reporting

A distribution licensee should provide the NERSA with a consolidated report based on its overall licensed area of supply. The licensee may internally report into divided geographical areas based on operational requirements.

10.2.7 Technical commentary and cause codes

The following additional key information should 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.

10.2 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.

11. Roles and responsibilities

11.1 National Energy Regulator of South Africa (NERSA)

11.1.1 NERSA will ensure the implementation of this code of practice by licensees through:

a) instructing the licensees on what elements of this code are to be implemented;

b) conducting audits as and when necessary to ensure that the relevant requirements of this code are implemented; and

c) an appropriate reporting system to ensure that licensees have implemented the requirements.

11.1.2 NERSA will, with regard to variations or exemptions form this code:

a) consider and approve (or otherwise) any application by a licensee or customer for a variation or exemption from the requirements of this document;

b) when considering such applications, consult the affected licensees on the impact of such variations or exemption on the power system; and

c) publish a list of sites approved for exclusion from the schedules, including those that are approved for exclusion on application from a licensee or customer.

NOTE NERSA will consider such exemptions in light of the motivation provided, the requirements of the System Operator, and the principles outlined in section 4.4.

11.2 Distribution licensees

Distribution licensees shall implement load reduction as instructed by the System Operator. This implementation shall be in terms of the requirements of this part of NRS 048.

11.3 Variations and exemptions

NERSA may from time to time issue variations or exemptions from this code of practice, where conditions require such variations or exemptions to be implemented outside of formal revisions of this code. Licensees may request such variations or exemptions from NERSA.

Annex A – Application template event (as defined in NRS 048-6) and exclusion application

(informative)

Name of Distribution Licensee:	
Date of major event (Start):	
Date of major event (End):	

High Level summary of the event and related circumstances leading to the occurrence of the exceedances

Criteria for discount (Criteria for event exemption as per NRS048 – 6)
Please indicate which criteria is the licensee applying for (Indicate with a X)

	Criteria B : Once of off non weather abnormal event Note: Affect ≥ 10% Licensee customer base OR ≥ 10% of installed MVA base (HV & MV quantified independently) over a period of 12 hours or longer

Condition 1: More than 10% of the installed customer base of the distribution licensee is without supply and the affected customers are without supply for 12 hours or longer;

OR

Condition 2: More than 10% installed MVA transformer base of the distribution licensee is without supply and the affected transformers are without supply for 12 hours or longer

Please select the condition and quantity the event meets for criteria B

Percentage of customers affected		Percentage of HV installed transformer base affected		Percentage of MV installed transformer base affected		Duration of event in hours

	Criteria C : Severe Weather event Note: Affect ≥ 5% Licensed customer base OR ≥ 5% of installed MVA base (HV & MV quantified independently)

Condition 1: A minimum of 5% of the customer base is affected and a valid severe weather related events that are reported by the weather service of South Africa

OR

Condition 2: A minimum of 5% (based on installed transformer capacity) is affected as a result of a severe weather related event.

Please select the condition and quantity the event meets for criteria C

Percentage of customers affected		Percentage of HV installed transformer base affected		Percentage of MV installed transformer base affected

	Criteria D.1. :Interruption caused by other distribution licensee When the intake point supplied by another distribution licensee is not available to supply the network or end customer.
	Criteria D.2.: Interruption caused by IPPs When an independent Power Producer (IPP) causes an interruption or requests for an outage, thus affecting the distribution licensee.
	Criteria D.3. :Staff, Contractors, Public or Animals Safety at Risk When the distribution licensee's personnel or public's personal safety are at risk in an attempt to restore supply to a network or end customer. The same condition would apply if a forced interruption is required to ensure the safety of the distribution licensee's personnel or public.
	Criteria D.4. :External Third party Caused When an interruption is caused by an external third party (i.e. public, direct end customer supplied by the distribution licensee or other external public utility services (i.e. Telkom, Road Works, SANRAL, Randwater, JRA etc.)
	Criteria D.5. :Interruption caused by other distribution licensee but not by its intake supply points Note: When another distribution licensee is the direct cause for an interruption, but their intake points to the distribution licensee are still available.

Annex A
(concluded)

OBJECTIVE FOR APPLYING
• The spirit of discounting abnormal and major events for power quality reporting is to identify and quantify the impact of the event/s that are outside the inherent operating and design environment of the affected network. • The intention of the abnormal event and major event discount process is to create a focus on the problematic sites or network areas that require management intervention and appropriate capital interventions. • Although an event can be categorized as a major event simply by meeting the defined criteria, there are recommended prescribed questions that the licensee would require to address. The purpose of the prescribed questions is to providing assurance that the event's impact to both the licensee's customers and networks are effectively managed and that the cause of the major event or exclusion event was not due to negligence on the part of the licensee
Prescribed questions to support application
a) An executive summary of the event and the circumstances surrounding the major / abnormal event.
Answer
b) Licensee is to provide assurance that the abnormal condition/s leading to the event are unique or that the licensee can expect reoccurrences for an indefinite time.
Answer
c) Licensee is to provide explanation why the event was not in the licensee's direct control, taking into account safety and legal obligations, and why should the event be excluded from the normal operational performance levels
Answer
d) Licensee to provide a summary of the actual escalation or emergency process followed by the licensee
Answer
e) Licensee to provide historical trends of the affected locations over a three year period (ensures that there are no repetitive root causes at same locations/networks)
Answer
f) Was there any negligence on part of the licensee, which directly resulted in the cause of the event or was there any negligence or poor management which had an impact on the magnitude of the incident i.e. restoration time, more customers etc.
Answer
g) Licensee to list the key lessons learnt and the mitigation or improvement plans to be implemented in preparation for similar future events
Answer
h) Licensee to list sequence of events including the protection philosophy applied to the affected network
Answer
i) Questions related to criteria B only (Non weather related) i. Licensee to provide inspection schedules and maintenance logs of equipment/network/plant, who's integrity was compromised resulting in the major event
Answer
j) Questions related to criteria C only (Weather related) NOTE Include all evidence relating to the severity of the storm including weather bureau and press articles i. Was there any storm hardening designs applied to the affected networks after past weather related occurrences ii. Does the licensee proactively analyse weather forecasts and thus mobilise resource in preparedness for a storm iii. Does the licensee analyse weather forecasting and thus mobilise resources to standby into areas where the probability of the storm impact is at its greatest. Provide evidence of such initiatives

Annex B – Example of network interruption performance index calculations

(informative)

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

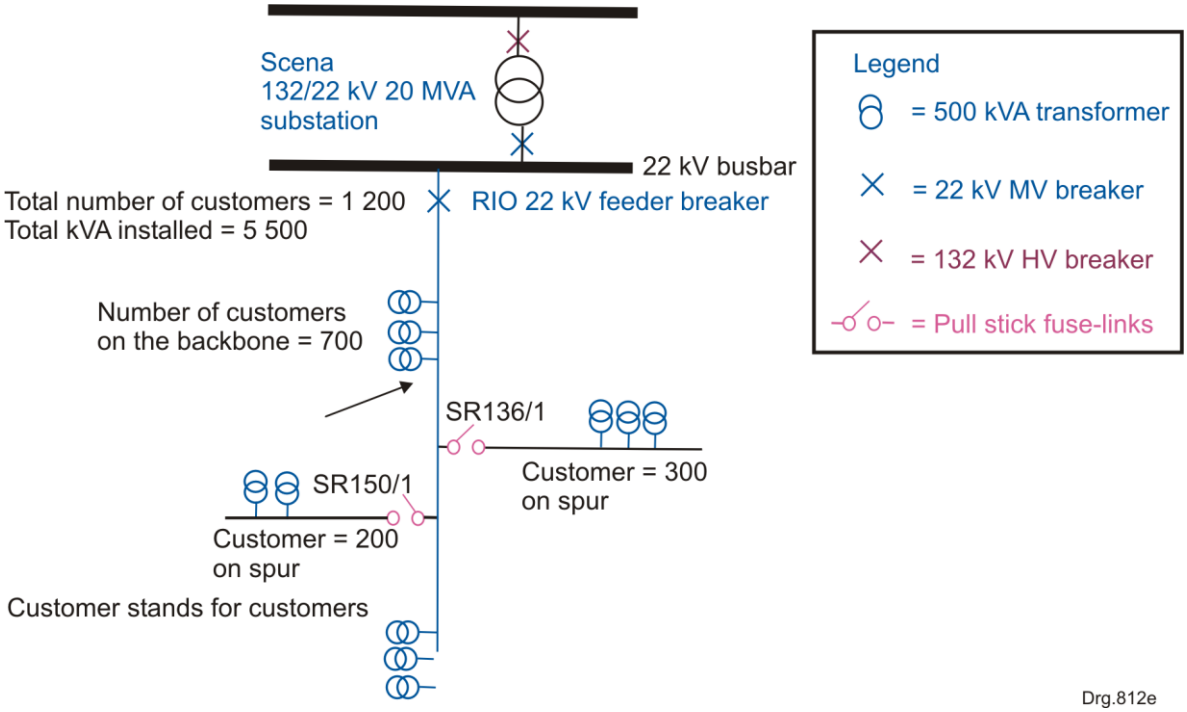


Figure B.1 — Example network

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 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 need 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 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 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:

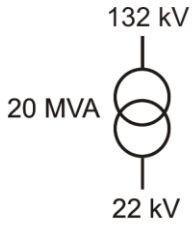
$$\text{MSLI} = \frac{(1{,}5 \times 3)}{5{,}5} = 0{,}82$$

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.

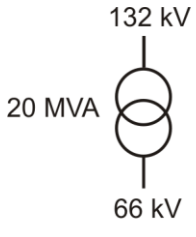
Annex C – Definition for transformer loss due to interruptions for different winding configurations

(informative)

C.1 Two-winding transformer



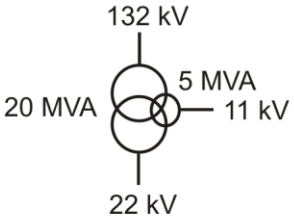
Use 20 MVA as a loss.



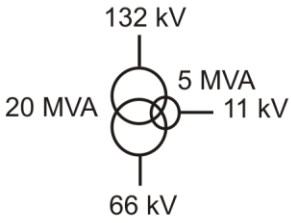
Coupling transformer no loss

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

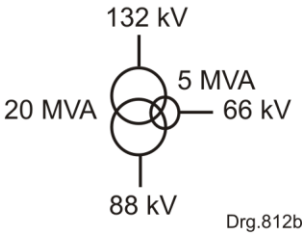
C.2 Three-winding transformer



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

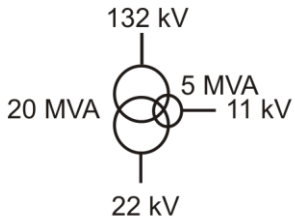


Use 5 MVA as a loss if customers are connected.

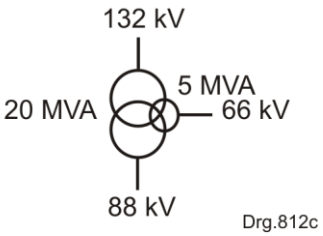


Coupling transformer no loss.

C.3 HV power transformer

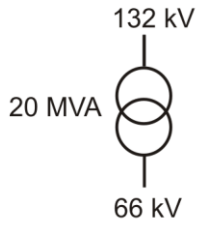


Use 20 MVA as a loss plus 5 MVA if customers are connected to tertiary.

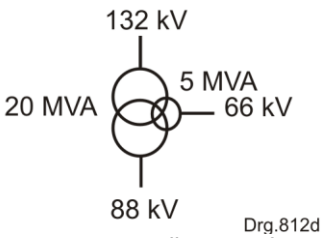


Use 5 MVA as a loss if customers are connected to tertiary.

C.4 Coupling transformer



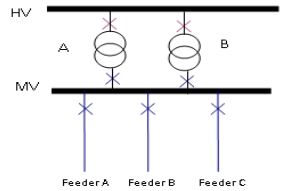
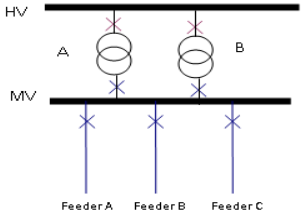
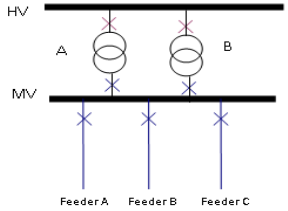
Coupling transformer no loss.



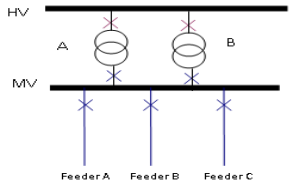
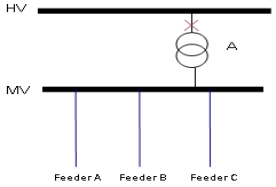
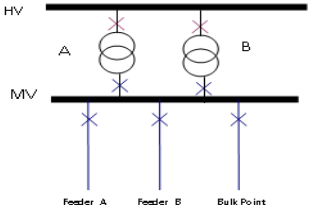
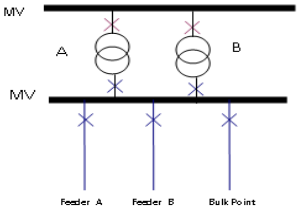
Coupling transformers no loss

Annex D – Example of a typical scenarios of transformer categories for MSLI tracing

(informative)

	Scenario	Transformer category	Include / exclude from MSLI	Include / exclude from HSLI	Diagram of network configuration
Example 1	A transformer bay (A) is isolated for maintenance or safety panel and the load being supplied by the MV busbar is not affected. Transformer B uninterrupted. NOTE Does not apply for a firm supply agreement with the customer.	Redundancy for transformer A	Not affected	Exclude	
Example 2	A transformer bay (A) is isolated for maintenance or safety panel and the load being supplied by the MV busbar is affected.	Supply Losses for transformer A	Include	Include	
Example 3	A simultaneous scheduled maintenance outage on both sides of the transformers (A and B) i.e. HV and MV. Optimize on outage.	Redundancy for transformer A and B	Include	Exclude	

Annex D
(continued)

	Scenario	Transformer category	Include / exclude from MSLI	Include / exclude from HSLI	Diagram of network configuration
Example 4	A simultaneous scheduled maintenance outage on both sides of the transformers (A and B) i.e. HV and MV, but NOT on all MV feeders (Feeder A and B only). Not optimizing outage, therefore HSLI is penalized.	Supply Losses for transformer A and B	Include	Include	
Example 5	If a substation configuration is designed to operate the transformer HV breakers for an MV feeder fault	Redundancy for transformer A	Include	Exclude	
Example 6	Substation configuration supplies reticulation feeders and a bulk point. If transformer A and B are interrupted	Supply Loss for transformer A and B	Include	Include	
Example 7	Substation configuration supplies MV feeders and a bulk point but transformers are coupling transformers. If transformer A and B are interrupted	Coupling for transformer A and B	Feeder A and B excluded if supplying another MV substation, but bulk point included	Excluded	

Annex D
(continued)

Example on the application of 33kV networks as a distribution voltage versus a reticulation voltage

According to the definition, if the voltage is used to demarcate between an HV and an MV voltage, then 33kV is classified as an MV voltage. However 33kV voltage can be applied as either a MV/HV voltage.

The example below is of two technical operating areas for a specific distribution licensee. Table 2 lists all performance data relating to the two areas over a defined time period.

Table 2: All SLI indices components of two selected technical operating areas for a specific time period

1	2	3	4	5	6	7	8	9
	Installed Load 33kV (MVA) including coupling transformers	**Coupling transformers 33kV (MVA)**	**Total installed MVA (for MV)**	**Total installed MVA for HV)**	**MSLI hours lost (All 33kV networks included)**	**33kV coupling transformer losses**	**Total losses for HV (MVAhrs)**	**Total losses for MV (MVAhrs)**
Technical Service area A	19,8 MVA	19,2 MVA	87 MVA	80 MVA	281,61 MVAhrs	268 MVAhrs	64,86 MVAhrs	3101 MVAhrs
Technical Service area B	141,1 MVA	73,4 MVA	207,4 MVA	700 MVA	1427,63 MVAhrs	1120 MVAhrs	1216 MVAhrs	5152 MVAhrs

Annex D
(continued)

Table 1: If the 33kV networks are to be classified as MV, irrespective of its application

1	2	3	4	5	6	7
	Includes all transformer and bulk loads (MVA)	As per definition in table 1: primary and secondary voltage of a transformer are within same voltage category i.e. MV or HV		Numerator of the MV SLI	MSLI (12month moving average)	HSLI (12month moving average)
	Installed Load (MV)	Coupling transformers 33kV (MVA) – Not included in MSLI	33kV losses where transformers are classified as coupling– Not included in MSLI	Total losses MV (MVAhrs)		
Technical Service area A	87 MVA	19,2 MVA	268	2833 MVAhrs lost	3,48 hours	4,05 minutes
Technical Service area B	207 MVA	73,4 MVA	1120	4032 MVAhrs lost	2,51 hours	8,68 minutes

Table 4: If the 33kV networks are to be classified as or HV, depending on its application for supplying

1	2	3	4	5	6	7
		If the application of the 33kV as a distribution or reticulation is applied then the transformer MVA as stated below are not classified as coupling but as supply MVA for the HV networks		Numerator of the HV SLI	MSLI (12month moving average)	HSLI (12month moving average)
	Installed Load (HV)	33kV (MVA) – Included in HSLI	33kV losses – Included in HSLI	Total losses HV (MVAhrs)		
Technical Service area A	99,2 MVA	19,2 MVA	268	332,86 MVAhrs lost	3,48 hours	16,77 minutes
Technical Service area B	773,4 MVA	73,4 MVA	1120	2336 MVAhrs lost	2,51 hours	15,1 minutes

Annex D
(concluded)

In the first scenario (table 2), the application of 33 kV as a distribution or reticulation voltage is not considered. In this scenario the 33 kV/22 kV and 33 kV/11 kV are classified as coupling transformers (As per definition in table 1) and therefore both the base and MVA hrs losses are not included within the calculations of the MSLI.

In the second scenario (table 3), the application of 33 kV as a distribution or reticulation voltage is considered. In this scenario the 33 kV/22 kV and 33 kV/11 kV are classified as supply transformers and therefore both the base and MVA hrs losses are included within the calculations of the HSLI.

In summary, the MSLI is not impacted by the application of the 33 kV networks as either a distribution or reticulation voltage, however the HSLI is impacted, as both the 33 kV base and losses are included within the HSLI indices calculations.