Rationalized User Specification

ELECTRICITY SUPPLY — QUALITY OF SUPPLY

Part 6: Distribution Network Interruption Performance Measurement and Reporting Standard

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Preferred requirements for applications in the Electricity Supply Industry
This Rationalized User Specification is issued by the NRS Project on behalf of the User Group given in the foreword and is not a standard as contemplated in the Standards Act, 1993 (Act 29 of 1993).

Rationalized user specifications allow user organizations to define the performance and quality requirements of relevant equipment.

Rationalized user specifications may, after a certain application period, be introduced as national standards.

Amendments issued since publication

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Foreword

This standard provides a future framework for the measurement principles, key performance measure definitions, high level event data quality assurance, data accuracy auditing requirements, and the requirements for distribution network interruption performance reporting in the South African Electricity Distribution Industry (EDI). The standard also provides the minimum requirements of an interruption performance management system for either the manual or automatic capturing and recording the interruption event data. The high level interruption cause codes are provided as a minimum requirement for associating of the interruptions with a cause code hierarchy. The relevant requirements for the disaggregation reporting as well as the annual regulatory reporting, benchmarking reporting and incentive based reporting are provided.

It is recognized that present systems of the distributor licenses do not meet the minimum requirements specified in this standard and therefore that the implementation of this standard will require resources, time and additional work. It is anticipated that the National Electricity Regulator of South Africa (NERSA) will specify the timeframe and compliance level for such implementation, in consultation with the various Distribution industry stakeholders.

The first edition of this part of NRS 048 was compiled by representatives of the South African Electricity Distribution Industry (EDI), in a working group appointed by the Electricity Suppliers Liaison Committee (ESLC). The working group membership included Government (DPE), the Distribution Industry, the NERSA, Eskom Distribution Division, Eskom Transmission Division, Eskom KSACS Division and end-customers. In compiling this standard, the working group was guided by key international developments such as: the IEEE P1366 standard “Full Use Guide for Electric Power Distribution Reliability Indices”, the work and recommendations of the international IEEE Task Force on Reporting Practises, the recommendations of Cigré Technical Report TB261, “Power Quality Indices and Objectives” the United Kingdom (UK) regulatory standard of the Office of Gas and Electricity Markets (ofgem), “Quality of Service Regulatory Instructions and Guidance” and the experiences and lessons learnt by the Eskom Distribution Division and the AMEU members.

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

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

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The contribution of the following person to the preparation, co-ordination and compilation of this part of NRS 048 is also acknowledged:

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

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

*Part 4: Application guidelines for licensees*

*Part 6: Distribution network interruption performance measurement and reporting standard network interruption performance measurement and reporting*

Annexes A, B, C and D of this standard are for information only.

Recommendations for corrections, additions or deletions should be addressed to the NRS Project Manager, c/o SABS, Private Bag X191, Pretoria, 0001.
Introduction

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

There is also a long term strategic benefit in that this standard will greatly assist the distributor licensees with the NERSA implementation of Incentive Based Regulation (IBR) and the national reporting of network interruption performance indices. The end objective is to cost effectively improve the reliability and availability of supply to the customers in South Africa. This can only be effectively done once there is a uniform, consistent and robust measurement and reporting of network interruption performance by all the distributor licensees in South Africa.

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

Caution needs to be exercised when conducting network interruption performance benchmark exercises. Interruption performance benchmarking requires careful consideration of not only the physical conditions related to the peer group members (e.g. network type and topography, environment, geography, network operating practises and human resource related elements), but also of the measurement, data collection and storage and reporting methods used. Through specifying the latter (taking international practises and key developments into consideration), this standard aims at providing an improved basis in South Africa, for undertaking such internal and international benchmarking activities into the future.

Key words

Network interruption performance, reliability and availability of supply; interruption cause codes, network interruption performance benchmarking, annual regulatory reporting and incentive based regulation (IBR).
NRS 048-6:2006      Draft

SPECIFICATION

Electricity supply — Quality of supply

Part 6: Distribution Network Interruption Performance Measurement and Reporting Standard

For applications in the Electricity Supply Industry

1 Scope

This part of NRS 048 specifies requirements for the measurement and assessment of the parameters for the reliability and availability of electricity supplied by the distribution licensees, for the purpose of reporting network interruption performance to the National Energy Regulator of South Africa (NERSA). The standard is predominantly focused on the primary plant performance but the key secondary plant related matters that impact the primary plant performance, are also considered and specified. This document also provides a basis for the internal interruption performance management purposes of the distributor licensees. The network events are defined in terms of their duration. The duration is heavily influenced by the internal and external processes of the distributor licensees, but this standard will ensure standard reporting processes amongst all the licensees. High level internal quality assurance processes, data completeness auditing guidelines and data accuracy measures are presented to prevent the distributor licences from artificially adjusting their performance statistics due to external regulatory pressures and internal business target setting and financial incentives.

The key aspects addressed in this standard are :

a) Interruption performance measurement and data collection requirements
b) Performance indices for reporting and the calculation method of these indices
c) Segmentation according to voltage group (low, medium and high voltages)
d) Segmentation of network and a basis for future segmentation of customer types for reporting purposes
e) Treatment and reporting requirements of major events
f) Handling of exclusions and inclusions of events for the various reporting requirements
g) Data collection of interruption cause codes according to a standard hierarchy
h) Requirements for the disaggregation for annual regulatory, benchmarking and incentive based regulation reporting
i) Data management and archiving and system related changes
j) Estimating the accuracy of reporting through event data audits

The standard deals with the norm and does not apply to premium power quality contracts with large customers. The required network interruption performance levels and associated costs to achieve these levels must be negotiated directly with the customer via specific supply agreements.

Note 1 : The interruption performance levels per customer categories are a long term regulatory reporting requirement as part of an effective and value adding IBR approach. The customer database of the distributor licensees will need the customer category identified and recorded for reporting as part of IBR. The relevant timelines and compliance level required for distributor licensees to start recording and reporting customer categories, will be decided by NERSA in consultation with all the relevant Distribution stakeholders.

Note 2 : The quality of service related measures (such as the number of planned interruptions starting and ending on time and the effective communication about pending planned interruptions) are not in the scope of this part of NRS 048 and are covered in NRS 047 (or future possible revisions). This standard only covers the technical performance aspects of the quality of supply provided to the customers.
An overarching principle of this standard for measurement practises by the distributor licenses, is that all the network events (momentary interruptions, sustained interruptions and temporary restorations of supply) experienced by the individual customers need to be captured and recorded in the relevant database of the distributor licensee. The network interruption performance reporting methodology will depend on the requirements specified in this part of NRS 048-6. The calculation and reporting process shall have clearly defined responsible and accountable persons, checks and balances and completeness and accuracy procedures and shall be auditable at any time by NERSA.

It should be noted that the network interruption performance indices used for regulatory purposes (such as incentive-based regulation) may change from time to time. The standard therefore provides for a range of indices that can be used for regulatory reporting and internal performance management by the distributor licensees. Some of these indices are customer-based (providing the average frequency and duration of interruptions experienced by the customers), or are load-based indices (providing the frequency and duration of loss of load) and others are network-based (providing the frequency and duration of interruptions on networks). Performance indices defining worst-served customers are also provided to ensure that the performance levels of individual customers are also monitored, reported and improvement projects implemented where necessary.

2 Normative references

The following specifications contain provisions which, through reference in this text, constitute provisions of this part of NRS 048. At the time of publication, the editions indicated were valid. All specifications are subject to revision, and parties to agreements based on this part of NRS 048 are encouraged to investigate the possibility of applying the most recent editions of the specifications listed below. Information on currently valid national and international standards and specifications can be obtained from the South African Bureau of Standards.

SANS 1816, Electricity supply — quality of supply : power quality instruments


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

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

NRS 048-4: Electricity supply — Quality of supply — Part 4: Application guidelines for distributor licensee’s.

3 Definitions and abbreviations

For the purposes of this part of NRS 048, the terms, definitions and abbreviations given in NRS 000 and NRS 047 apply and should be consulted. Some selected terms are repeated in order to promote the understanding and correct application of this standard.

3.1 Definitions

3.1.1 Alarms: Network or equipment indication warnings received for primary or secondary plant in an abnormal state. This may be due to a possible network fault or a warning indication of faulty equipment.

Note: Typical examples of alarms are breaker alarms, transformer alarms and AC/DC alarms.

3.1.2 Alternative feed: When supply to a customer is interrupted for a short period and an alternate supply is provided from another network or supply source.
3.1.3 **Applet:** A software application that has limited features, requires limited memory and is usually portable between operating systems.

3.1.4 **ARC:** Auto reclose operation. 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.

3.1.5 **Audit:** process of inspecting the procedures, facilities and other relevant items to confirm compliance with requirements.

3.1.6 **Auxiliary transformer:** Any transformer that has been installed and supplied from a supply transformer with the purposes of supplying auxiliary equipment or supply points.

3.1.7 **Circuit:** An arrangement of conductors for the purpose of carrying electrical energy. 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.

3.1.8 **Customer:** A person or legal entity who has an electricity supply agreement with the relevant distributor licensee. This also includes temporarily disconnected customers but excludes illegally connected customers.

*Note:* For the purposes of network interruption performance calculations, the individual customer count can be taken as the number of points of supply or premise. The customer count methodology needs to be clearly indicated, consistently applied and provided to NERSA during annual reporting.

3.1.9 **Customer network link (CNL):** The customer network link is an index that evaluates the completeness of the data used in the data connectivity model to determine the total number of customers physically connected to the transformers. It is expressed as a percentage (%) of the total number customers connected to the network.

*Note 1:* A CNL of 95% would indicate that 95% of the physically connected customers in the network are in the customer database and their associated interruptions are counted as part of the network interruption performance index calculations.

*Note 2:* A customer disconnected for not paying or tampering with their meter will not be counted in an interruption.

*Note 3:* It is the responsibility of the distributor licensee to ensure the accuracy of the CNL at all times. A high percentage CNL does not necessarily imply an accurate CNL. Future revisions of this standard will address methods to report the CNL accuracy and the specific accuracy level requirements per voltage group.

3.1.10 **Data connectivity model:** Data connectivity refers to complete and accurate model of the number of customers connected to a transformer affected by an interruption. 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.

3.1.11 **Distributor licensee:** Refer to the definition of licensee in terms of the distribution of electricity. The terms licensee and distributor licensee are interchanged in this document.

3.1.12 **Emergency:** Any condition that poses an immediate and direct threat to life or could possibly cause severe damage to the plant of the distributor licensee or customer. These associated interruptions are dealt with immediately by the distributor licensee and recorded under the emergency sub-category of the fault category.

3.1.13 **Extra high voltage (EHV):** The set of nominal voltage levels that are used in power systems for bulk transmission of electricity in the range \(220 \text{kV} < U_n \leq 400 \text{kV}\). [NRS 048-2]

3.1.14 **Frequency:** The frequency of alternating voltage generated by power system generators.

*Note:* In South Africa a standard frequency of 50Hz is used.

3.1.15 **High voltage (HV):** The set of nominal voltage levels that are used in power systems for bulk transmission of electricity in the range \(44 \text{kV} \leq U_n \leq 220 \text{kV}\). [NRS 048-2]
3.1.16 **Interruption:** An 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 3 s. [NRS 048-2]. The interruption can be a sustained interruption, a momentary interruption or a temporary restoration of supply during fault finding on one or more phases of supply. The interruption can also be planned or unplanned.

3.1.17 **Licensee:** A body, licensed by the National Energy Regulator of South Africa, that generates, transmits or distributes electricity.

3.1.18 **Live work:** Live work conducted on a section of network or plant using standard accepted maintenance techniques during energised conditions where the supply to the customer was not lost.

3.1.19 **Lock out:** The final operation of a recloser or circuit breaker in an attempt to isolate a persistent fault. The current carrying contacts of the interrupting device are locked open under these conditions.

3.1.20 **Losses:** Losses are defined as energy not supplied by the network due to a network interruption of supply measured in MVA.Hours. The figure for MVA is based on the installed transformer MVA rating or the transformer name plate rating and the hours figure is based on the duration of the network interruption.

3.1.21 **Low voltage (LV):** The 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). [SABS 1019]

3.1.22 **Major event:** This is an extraordinary event that exceeds the reasonable design (best engineering design methodologies), or the expected normal operational limits of the electrical networks of the distributor licensee. These events can also be due to very large scale natural events affecting a large customer base or many networks. Refer to the “force major” definition in NRS 048-2. The criteria for major event reporting are covered in section 5.2.3.

3.1.23 **Medium voltage (MV):** The set of nominal voltage levels that lie above low voltage and below high voltage in the range \( 1 \text{kV} \leq U_n < 44 \text{kV} \) [NRS 048-2].

3.1.24 **Network:** Is the electrical infrastructure over which energy is transported from source to point of consumption and comprises of a combination of different circuits.

3.1.25 **Network event investigation:** The action whereby the cause or contributory cause of a network event analysed during an enquiry. The objective is to identify and formally report causes and corrective actions where there was a failure by people or plant. The procedure is initiated by the appropriate investigation triggers as defined by the distributor licensee.

3.1.26 **Network interruption performance:** The 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 distributor licensee’s network.

3.1.27 **Network event:** Any occurrence or series of events on the network of the distributor licensee, or any other nearby connected other distributor licensee, or Transmission and Generation licensees, that results in either a single or series of sustained or momentary interruptions of supply to the customer.

3.1.28 **Unplanned interruptions:** These interruptions are due to network fault (transient or permanent) conditions or an unplanned interruption of supply due to protection mal-operation or switching errors by the distributor licensee. These interruptions exclude those caused by load reduction related events.
a) Unplanned interruptions on HV networks

An interruption occurs when one or more phases of a supply to a single customer or group of customers are disconnected for a period exceeding 3s. Interruptions refer to the complete (100%) voltage loss on one or more phases.

a.1) Momentary interruptions (HV): Unplanned interruptions in the range > 3s to ≤ 1 minute.

a.2) Sustained interruptions (HV): Unplanned interruptions with a duration > 1 minute. In general a 1 minute limit differentiates all automatic reclose operations (ARCs) from events involving manual operator intervention.

Note 1: The 1 minute classification aligns with the commonly used international classification of 1 minute for sustained interruption of supply for transmission distributor licensee’s.

Note 2: The requirements of IEC 60056 specified distribution circuit breakers (i.e. kiosk or dog box breakers) are that at rated conditions (i.e. full rated fault current), a dead time of 0.3 seconds for the first delay and a dead time of 3 minutes for the second delay, of the circuit breaker duty cycle sequence be used. The majority of transient events should be cleared in the first 0.3 seconds dead time. This may result in very limited cases of 3 minutes dead time momentary related events been incorrectly recorded as sustained interruptions on HV networks.

b) Unplanned interruptions on MV and LV networks

An interruption occurs when one or more phases of a supply to a single customer or group of customers are disconnected for a period exceeding 3s. Interruptions refer to the complete (100%) voltage loss on one or more phases.

b.1) Momentary interruptions (MV/LV): Unplanned interruptions in the range > 3s to ≤ 5 minutes.

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 shall be counted as separate momentary interruptions. The individual momentary interruptions are part of the MAIFI calculation and the momentary interruption event (comprising of 2 to 4 subsequent operations) forms part of the MAIFIe calculations.

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

b.2) Sustained interruptions (MV/LV): Unplanned interruptions with a duration > 5 minutes

3.1.29 Pareto analysis: (also known as the 80-20 principle) This is an engineering rule-of-thumb analysis technique that identifies the 20% of phenomena that result in 80% of consequences. The subsequent selection of the most effective actions based on the identified 20% that deliver the total benefit reasonably close to the maximal possible one.

3.1.30 PTO/PTS: Permission to operate/permission to switch. The network control centre of the distributor licensee hands over network control responsibility temporarily to the field staff, so allowing them to operate and switch the network without the supervision of the control centre. All operating shall recorded real time or manually recorded in the operating log sheet and afterwards manually captured into the interruption management system or database.

3.1.31 Pre-arranged Event: A 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.

3.1.32 Re-interruption: The subsequent sustained unplanned interruption (as defined for MV and HV networks) 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. The re-interruptions are only valid if the cause of the subsequent interruptions was at the same physical location on the network as the original interruption and occurred less than 3 hours after the original interruption.

3.1.33 Reporting period: The reporting period for the network interruption performance indices is by default assumed to be a calendar year window.
3.1.34 **Stored procedures:** A set of software procedures that summarises all interruption (frequency and durations) and customer information into aggregated tables so that the information system can automatically produce the network interruption performance indices based on the tables.

3.1.35 **Step restoration:** The process of restoring supply to individual customers or an re-energising an interrupted network in stages over a period of time. The restoration of supply to the customers would be conducted in phases with eventually all the affected customers having supply restored.

3.1.36 **Third party:** Any external person or company that is not part of the customer or contracted by the customer or the distributor licensee. This excludes the generation licensee, transmission licensee or adjacent distributor licensee.

3.1.37 **Total number of customers served:** The total number of customers connected (including the disconnected customers) to the networks. This number is used as a denominator in the network interruption performance index calculations and needs to be as accurate as possible.

3.2 **Abbreviations**

3.2.1 **CNL:** Customer Network Link
3.2.2 **IBR:** Incentive Based Regulation
3.2.3 **ESI:** Electricity Supply Industry
3.2.4 **IEEE:** Institute of Electrical and Electronic Engineers
3.2.5 **GIS:** Geographic Information System
3.2.6 **HVDC:** High Voltage Direct Current
3.2.7 **N/O:** Normally open point
3.2.8 **NERSA:** National Energy Regulator of South Africa
3.2.9 **OMS:** Outage Management System
3.2.10 **QA:** Quality Assurance
3.2.11 **QOS:** Quality of Supply
3.2.12 **RTU:** Remote Terminal Unit
3.2.13 **SCADA:** Supervisory Control And Data Acquisition
3.2.14 **SWER:** Single Wire Earth Return System

4 **Interruption performance reporting system minimum requirements**

The minimum requirements for any network interruption reporting system are described below. It is recognized that the present functionality of computer systems and the capturing and reporting procedures of some distributor licensees, do not meet the requirements specified in this standard and therefore that the implementation of this standard will require time and additional work.

Note: The NRS 048-4 standard provides additional guidance for system requirements that may further enhance the interruption performance reporting and interpretation of the measured statistical trends.
Refer to Annex A for additional information on the recommended user interface functionality and report scheduling procedures.

### 4.1 Capturing of network events functionality or procedures

The capturing of network events functionality or procedures shall allow for:

a) The facilitation of the structured capture of interruption of supply events. This shall include the capture of telemetered and non-telemetered events occurring on the networks.

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

c) The interruption cause code hierarchy capturing as per the requirements in section 8. It is recommended that the system shall support all cause code text up to 32 characters long.

d) Allow for a complete customer connectivity model from the HV system to the LV customers connected to the MV/LV transformers. The customer connectivity model shall be maintained and updated regularly by the distributor licensee.

The connectivity model should have the following recommended minimum data completeness levels:

- i. HV customers > 99%
- ii. MV customers : > 90%
- iii. LV customers connected to the MV/LV transformers : > 65%

Note: The Distributor licensee needs to justify to the NERSA about the appropriate and practical required customer connectivity levels for HV, MV and LV customers. The Distributor licensee will need to justify to NERSA for levels less than the above recommended levels based on their particular operating environment, business circumstances and resource constraints.

e) The location of network faults based on events and information received via SCADA, customer calls logged at the call in centre and signals received from protection devices on the network. It is recognised that not all distributor licenses will have full SCADA coverage.

f) Allow for the captured event data to be merged and filtered into logical formats or formats specified by the distributor licensee.

g) Provide diagnostic procedures to be implemented to identify the missing or incorrect plant location data.

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

### 4.2 Data correction and manual editing

The functionality for data correction and manual editing shall allow for:

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

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

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

d) Allow for the downstream customer information to be automatically re-calculated and the overall network interruption performance indices to be adjusted accordingly.
4.3 Reporting requirements

a) Comprehensive reporting features including web-based reports shall be provided.

b) The reporting functionality shall allow for the following:
   i. Geographical reporting hierarchy (total system, district or area, substation and per network)
   ii. Reporting per voltage level and pre-determined voltage groups
   iii. Reporting per planned work and unplanned interruptions
   iv. Reporting the network interruption performance indices monthly (actual) and per yearly (12 months) window

c) The following network event statistics and relevant information shall be reported on:
   i. Date and time of the network event
   ii. Name of the network affected
   iii. Number of interruptions
   iv. Number of customers affected
   v. Number of large or major customers affected (including downstream)
   vi. Customer hours lost
   vii. Transformer kVA affected
   viii. Number of interruptions per customers interrupted
   ix. Total hours
   x. Total number of hours per interruption
   xi. The frequency and duration of events per cause code categories (e.g. pareto analysis)
   xii. Individual customer interruptions can be created at each load point through user selection of the customer from a list of all connected customers.
   xiii. Total line length per network
   xiv. Live work reports (optional)
   xv. Breakdown reports for the interruption categories
   xvi. Number of momentary interruptions
   xvii. Number of sustained interruptions

xviii. The type of customer affected by an interruption shall be recorded and reported. This may mean a link to the customer database or billing system of the distributor licensee. The following customer categories are recommended to be used:
   a) Residential
   b) Agricultural
   c) Heavy industrial
   d) Light industrial
   e) Commercial
   f) Electrification

The definitions of each category need to be established by the relevant distributor licensee based on sound engineering judgement and the energy used by the customers.

RK to provide generic definitions of the above self requested customer categories

4.4 Manual and automatic capturing systems

Refer to Annex B for additional information on the manual and automatic capturing of events by interruption performance reporting systems.
5 Interruption categories for reporting

In order to facilitate the various reporting requirements, categories and associated sub-categories of interruptions are defined below.

Note: When providing interruption performance data, the exclusion of any categories (or sub-categories) of interruptions shall be clearly specified by the distributor licensees with the submission to NERSA. It is anticipated that NERSA will clearly define which categories need to be included or excluded in the reporting.

5.1 Categories and sub-categories

The categories and sub-categories for classifying the interruption types are listed below (the application of the categories is defined in sections 5.2 to 5.5):

5.1.2 Unplanned interruption (“U”)
   a) Network event
   b) Emergency
   c) Major event

5.1.3 Planned work (“P”)
   a) Routine
   b) Pre-arranged
   c) Major event

Note 1: The 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 2: Although not a minimum requirement, some distributor licensees may wish to log the positive impact of live work on planned work performance. A category for live work may therefore be utilised 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. The costs for live work may be used by distributor licenses in IBR negotiations with NERSA, as a strategy to improve the network interruption performance level. 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.

5.1.4 Customer related (“C”)
   a) Customer caused
   b) Customer requested

5.1.5 Intake supply related (“S”)
   a) Unplanned
   b) Planned

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

5.2 Application of unplanned interruption category

5.2.1 Network event
An interruption shall be categorised as a “network event” where any one of the following applies:

   a) The interruption is due to network fault (transient or permanent) conditions or an unplanned interruption of supply due to protection mal-operation or switching errors by the distributor licensee.

Note: Typical examples of network events are line or cable failures, equipment failures, fuse failures and incorrect network switching.
b) The affected customers did not receive any notification of the pending loss of supply.

c) Insufficient notification time (as defined by NRS 047 or the customer contract) was provided to the customer.

Note: Currently NRS 047 specifies a 48 hours notification time for planned interruptions customers.

5.2.2 Emergency
An interruption shall be categorised as an “emergency” where it can specifically be shown that a condition existed that posed an immediate and direct threat to life, or could possibly have caused severe damage to the plant of the distributor licensee or customer.

5.2.3 Major event
A major event is considered to occur when there are conditions or events on the network that result in many customers affected or installed MVA lost or results in supply restoration times longer than that expected under normal conditions.

The major events for MV networks as defined below, shall be removed from the network interruption performance indices and reported separately by the distributor licensee. The intention is to report the actual underlying performance level that is not distorted by abnormal events occurring out of the distributor licencees control. The underlying performance is what is critical for the successful implementation of IBR.

5.2.3.1 Major event criteria A (for annual regulatory reporting and distributor licensee comparison)
This is for incidents defined according to a fixed quantum
An interruption shall be categorised as a “major event” for external distribution comparison reporting purposes, where any one of the following conditions are met:
- a) More than 5 000 customers are affected and are without supply for 18 hours or longer due to a single event
- b) More than 500 MVA.hours of the aggregated HV supply side ratings of the downstream installed transformer capacity and off for 2 hours or longer

Note 1: The firm transformer capability or redundancy needs to be removed for condition b) above to prevent double reporting and only the supply side transformer capacity used in the MVA.hours calculation.

Note 2: The major event criteria A will allow for equitable and consistent comparison of small and large distributor licensees in South Africa. Some of the larger distributor licensees may report many major events according to criteria A, due to the large customer base or large installed MVA. Some of the smaller distributor licensees may report many major events. The intention is to normalise the major events for large and small distributors.

5.2.3.2 Major event criteria B (for annual reporting and year on year licensee performance self comparison)
An interruption shall be categorised as a “major event” for reporting where any one of the following conditions are met:
- a) More than 10% of the installed customer base of the distributor licensee is without supply for 12 hours or longer
- b) More than 10% installed MVA transformer base of the distributor licensee is without supply for 12 hours or longer
- c) Through a specific agreement in writing between the relevant distributor licensee and the NERSA and that is published on the NERSA website in the public domain.

Note 1: This criteria for major events using a fixed number criteria will allow for the aggregation of South African statistics and assist in determining the underlying performance trends for IBR purposes.

Note 2: The major event criteria will be applied as per the formal areas of distribution of each distributor licensee. Refer to section 10.1.4 for additional information.

5.2.3.3 Major event criteria C reporting (for internal licensee reporting)
The criteria shall be defined by the distributor licensee as part of its internal performance management and reporting process.
5.3 Application of planned interruption category

5.3.1 Routine
A planned interruption shall be categorised as a “routine” where one of the following apply:

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

Note 1: Routine planned work is usually for the purposes of construction, preventative maintenance, refurbishment or repair.

Note 2: Currently NRS 047 specifies a 48 hours notification time for customers.

5.3.2 Pre-arranged
A planned interruption shall be categorised as a “pre-arranged” when a planned and co-ordinated interruption of supply to the customer or group of customers involves a number of successive switching operations resulting in numerous interruptions, that are all counted as a single planned interruption.

The following requirements need to be noted and implemented:

- a) The supply needs to be restored to the customer on the notified time as originally scheduled. If the distributor 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 the later start time.

- b) The total duration of the interruption must 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 distributor licensee’s quality of service provided.

5.3.3 Major event
A planned interruption shall be categorised as a “major event” where any one of the criteria specified in section 5.2.3.1, 5.2.3.2 and 5.2.3.3 apply. This is due to the fact that the interruption complying with the major event criteria can be either an unplanned or planned interruption, depending on the specific conditions.

5.4 Application of customer related category

5.4.1 Customer caused
A customer related interruption shall be categorised as a “customer caused” when an interruption of supply occurs on the distributor licensee’s network that is caused directly by the customer concerned, or an appointed agent working on the customer’s item of plant.

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 carried out on the customers own plant that causes a fault or a contractor hired by the customer causing a fault on the customers plant.

Note 2: If a customer is disconnected owing to non-payment and then re-connected, then this is regarded as a customer caused event.
Note 3: It is the responsibility of the distributor licensee to ensure adequate planning and protection co-ordination (i.e. the use of group fusing methodology) to limit the impact of customer caused interruptions on the other nearby customers on the network. The discipline of the field staff in replacing failed fuses with the correctly rated fuses, needs to also be encouraged.

5.4.2 Customer requested
A customer related interruption shall be categorised as a “customer requested” when there is an interruption of supply requested by the customer for the maintenance of their own plant, upgrading 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 interruptions.

Note: Typical examples of customer requested category interruptions are customer planned work carried out on the customers own plant, customer requested switching or operating or a customer requesting unplanned ad hoc maintenance work by the distributor licensee at the substation.

5.5 Application of intake supply related category

5.5.1 Unplanned
An intake supply related interruption shall be categorised as “unplanned” when there is an unplanned and uncoordinated interruption of supply occurring on the network of the distributor licensee, that was not caused directly by the affected licensee or its customer and their appointed agents, working on their plant. These interruptions are caused by adjacent other generation, transmission distribution or distributed generation licensees.

5.5.2 Planned
An intake supply related interruption shall be categorised as “planned” when there is a planned and coordinated interruption of supply occurring on the network of the distributor licensee, that is not caused directly by the affected licensee or its customer and their appointed agents working on their plant. These interruptions are caused by adjacent other generation, transmission distribution or distributed generation licensees.

The initiating other generation, transmission, distribution or distributed generation licensees of the planned intake of supply interruption must inform the affected distributor licensee of the planned interruption at least 7 working days ahead of time in writing and verbally to the responsible person.

These events also include customer voluntary load reduction related (load shedding or swinging) caused interruptions of supply to which the 7 working days notification requirement will not apply. These interruptions need to be carefully assessed, recorded and reported as a separate sub category within the planned intake supply category.

5.6 Related loss of supply and single phasing events

5.6.1 Voluntary load reduction events
Customer voluntary load reduction events are characterised by the curtailment, partial curtailment, or reduction of customer load but no actual loss of supply. Customer voluntary load reduction events shall not be classified as interruptions, but shall be assessed and reported separately.

Note: NRS 048-2 provides the requirements of voluntary load reduction events.

5.6.2 Single phasing events
Where one or more phases to a 3-phase customer are disconnected, and the duration is longer than 3 seconds, such an event is defined as a single phasing event and reported separately by the distributor licensee. This is also loosely referred to as “single phasing” and shall be recorded as an unplanned interruption.
6 Definitions of network interruption performance indices

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

a) Availability of supply – the average duration of an interruption of supply experienced by the customer.

b) Reliability of supply – how frequently on average an interruption of supply is experienced by 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.

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

f) Network reliability – the frequency of interruptions occurring on network normalised to 100km.

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 HV networks (> 1 minute window) and MV and LV networks (> 5 minutes window). This time requirement is to differentiate between an automatic (system) and manual (operator) intervention to restore network supply to the customer on the HV and MV networks.

The data capturing requirements are set out in section 4.3 b).

Note 1: The 5 minute 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 IEC 60056.

Note 2: The 1 minute window for HV networks aligns with the commonly used international classification for transmission distributor licensees.

Refer to Annex C for an illustrated example of the network interruption performance index calculations.

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

Any re-interruption must occur less than and excluding 3 hours 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 occurring 3 hours or longer after the previous interruption, will be counted as a new interruption, even if occurring at the same location on the network.
A simplistic rule-of-thumb is provided below to promote the understanding on the re-interruption concept.

a) Breaker trip – close - trip < 3 hours : re-interruption
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 an 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, then entire network then has supply permanently restored. The network event would be reported as all the customers experiencing 1 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 back to the customer as soon as possible after a fault. The distributor licensee is still encouraged (and in future incentives will be made available) to restore supply to the customers in the shortest possible time through distribution automation, reduced travelling time etc.

Note 2: The international average for CAIDI is around 2 hours. Setting a re-interruption time window is 3 hours would therefore be appropriate. The UK regulator (OFGEM) also specifies a re-interruption time of 3 hours.

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

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

Note 5: A potential future IBR environment (similar to the UK IBR environment) could be a focus on both SAIFI and SAIDI over the incentive period (3-10 years), but with more emphasis on improving SAIDI. The SAIFI could be sustainably improved by 0.5% to 1.0% per annum with SAIDI sustainably improved by 15-30% over the incentive period. To improve SAIFI requires a long term approach while improving SAIDI can be done over the short to medium term. It must be noted that IBR does not only relate to technical performance but an entire business efficiency and mobilisation step change that cuts across all the departments, value chains, processes, systems, data, financial and human resource aspects of a distributor licensee.

Refer to Annex C for an example of network interruption performance index calculations.

### 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:

\[
SAIFI = \frac{\text{Total number of customer interruptions p.a.}}{\text{Total number of customers served}} \tag{1}
\]

### 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:

\[
SAIDI = \frac{\sum \text{customer interruption durations p.a.}}{\text{Total number of customers served}} \tag{2}
\]

### 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:

\[ CAIDI = \frac{\sum \text{customer interruption durations p.a.}}{\text{Total number of customer interruptions}} \]  \hspace{1cm} (3)

Or expressed as:

\[ CAIDI = \frac{\text{SAIDI}}{\text{SAIFI}} \]  \hspace{1cm} (4)

Note: The general case is for \( \text{CAIDI} < \text{SAIDI} \), 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 interrupted 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:

\[ CAIFI = \frac{\text{Total number of customer interruptions p.a.}}{\text{Total number of customers interrupted}} \]  \hspace{1cm} (5)

### 6.2.7 ASAI (Average Service Availability Index):

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

\[ \text{ASAI} = \frac{\text{Customer hours service availability p.a.}}{\text{Customer hours service demand p.a.}} \]  \hspace{1cm} (6)

Note: There are 8760 hours in a non-leap year and 8784 hours in a leap year.

Alternatively ASAI can be expressed as:

\[ \text{ASAI} = 1 - \frac{\text{SAIDI}}{8760} \]  \hspace{1cm} (9)

### 6.2.8 HSLI (HV Supply Loss Index):

The HSLI of a network indicates the average transformer supply loss duration of the HV plant installed due to sustained interruptions. It is a measure of the HV transformer unavailability and is expressed as hours per month. Only the HV supply transformers are used as part of the calculation and HV coupling transformers are excluded. The HSLI will also include HV plant that has been affected by MV related through faults on the network. Mathematically HSLI can be expressed as:
6.2.9 MSLI (MV Supply Loss Index): The MSLI of a network indicates the average transformer supply loss duration of the MV plant installed due to sustained interruptions. It is a measure of the MV transformer unavailability and is expressed as hours per month. Only the MV supply transformers are used as part of the calculation and MV coupling transformers are excluded. The MSLI will also include MV plant that has been affected by LV and HV related interruptions on the network. Mathematically MSLI can be expressed as:

$$\text{MSLI} = \frac{\sum \text{MVA, Hours, lost per month}}{\text{Installed MV MVA base}}$$  \hspace{1cm} (11)

6.2.10 Interruptions/100km (Number of interruptions per 100km): The Interruptions/100km of a network indicates the total number of interruptions (unplanned interruptions and planned work) experienced normalised per 100km of circuit length per annum. It represents the normalised reliability of supply per network. It is commonly measured as the number of interruptions per 100km per annum.

Mathematically Interruptions/100km can be expressed as:

$$\text{Interruptions/100km} = \frac{\text{Total number of interruptions p.a. x 100}}{\text{Total line length (km)}}$$ \hspace{1cm} (12)

Note 1: Cable and overhead lines shall be reported separately

Note 2: This can be reported separately as the planned work and unplanned interruptions (faults/100km) components

6.3 Momentary interruption indices

The following network interruption performance index definitions all refer to momentary interruptions on HV networks (≤ 1 minute) and MV networks (≤ 5 minutes). The indices are a measure of the transient interruption performance of a network, or the auto recluse (ARC) performance of the circuit breakers.

The number of customers affected that are identified shall be in the same manner and accuracy as for sustained interruptions. If the distributor 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 provided in any report submissions. Otherwise, the licensee shall provide accurate and reliable information on the actual network configuration at the time.

6.3.1 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:

$$\text{MAIFI} = \frac{\text{Total number of customer momentary interruptions p.a.}}{\text{Total number of customers served}}$$ \hspace{1cm} (14)
6.3.2 MAIF\text{le} (Momentary Average Interruption Frequency Index of events) : The MAIF\text{le} of a network indicates how often an average customer connected would experience a momentary event per annum. A momentary event may comprise of one or more momentary interruptions.

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

Mathematically MAIF\text{le} can be expressed as :

\[
\text{MAIF\text{le}} = \frac{\text{Total number of customer momentary interruption events p.a.}}{\text{Total number of customers served}}
\]

(15)

6.3.3 MInterruption/100km (Number of momentary interruptions per 100km) : The MInterruptions/100km of a network indicates the total number of momentary interruptions (unplanned interruptions and planned work) experienced normalised per 100km of line length per annum. It is commonly measured as number of ARC's.

Mathematically MInterruptions/100km can be expressed as :

\[
\text{MInterruptions/100km} = \frac{\sum \text{Network momentary interruptions p.a.} \times 100}{\text{Total line length (km)}}
\]

(16)

6.4 Worst served customers measures

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

6.4.1 Percentage of customers with single supply sustained interruptions of longer than 18 hours per annum per event

6.4.2 Percentage of customers experiencing 60 or more sustained interruptions per annum

6.4.3 Percentage of customers experiencing 30 or more individual supply sustained interruptions and that also last longer than 18 hours each per annum

Note : The quantum indicated above can be adjusted over time as more data collection is made available. It is anticipated that the quantum’s will be adjusted in the next revision of this standard (NRS 048-6 version 1)

6.5 Customer supply restoration times

The following information below shall be the methodology to be applied by all the distributor licensees for the calculation of customer supply restoration times after a unplanned interruption for the required NRS 047 reporting :

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

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

The individual customer interruptions will be summated and a count of the number of customers affected performed according to the NRS 047 defined categories.
c) The results will be expressed cumulatively and as a percentage of the total number of customers interrupted and drawn on the required graph format. The X-axis will have the NRS 047 restoration time categories and the Y-axis will have the percentage of customers with supply restored. Refer to the below example for further clarity.

Note: The current NRS 047 duration categories are 1.5, 3.5, 7.5 and 9.5 hours.

Figure 1 below provides an example of the NRS 047 restoration of supply times after unplanned interruptions. The distributor licensee A has good restoration of supply times while distributor licensee B has poor restoration of supply times (not meet the NRS O47 requirements).

![Figure 1: Example of NRS 047: restoration of supply times after unplanned interruptions](image)

6.6 Customer segmentation reporting

The network interruption performance levels per customer categories are a long term regulatory reporting requirement as part of IBR. The customer database of the distributor licensees will need the customer category identified and maintained for reporting as part of IBR. The customer categories will be finalised in future. The relevant timelines required for distributor licensees to start reporting customer categories will be decided by NERSA in consultation with all Distribution stakeholders.

The following customer categories are recommended to be used:

a) Residential
b) Agricultural
c) Heavy industrial
d) Light industrial
e) Commercial
f) Electrification

Note: The future proposed customer categories will be based on the key high level categories. The intention is not to have detailed customer categories that will require high maintenance by the distributor licensee.

RK to provide generic definitions of the above self requested customer categories.
7 Network event data auditing and validation

7.1 Network events to be validated
All the following network events shall be validated and confirmed by the distributor licensee:

a) Affecting and not affecting the connected customers
b) Resulting and not resulting in a loss of supply
c) Secondary plant (protection and alarms)
d) Momentary and sustained interruptions
e) Planned work and unplanned interruptions

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

7.2 Network event and interruption times

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

a) The first report of loss of supply of a network or customer, or the report of a item of equipment has faulted on a section of network
b) The network or equipment is automatically or is intentionally disconnected from the system

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

a) The customer or a third party contacts the licensee to inform them of the interruption
b) An automatic alarm received by the licensee indicating an interruption
c) A staff member of the licensee identifying the existence of an interruption

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

a) Supply has been restored to all the affected customers for 3 hours and longer. An interruption occurring after 3 hours or longer after the previous interruption, is to be counted as a new and separate interruption.

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

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

7.3 Clock stopping for end times
The counting of the duration of the interruption shall be “clock stopped” when either of the following occurs:

a) If access to the customer or substation is not available or prevented despite the best efforts of the distributor 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 in accessing the customer or substation. These records are to 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 is reached. The licensee should keep accurate and reliable records about the
requested delay by the customer. These records are to be made available to be audited on request by the customer or the NERSA.

c) When the restoration of supply has to be stopped due to safety issues, life threatening situations, emergency services, government authorities or other licenses preventing access or requesting 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 are to be made available to be audited on request by the customer or the NERSA.

7.4 Permission to operate/permission to close (PTO/PTS)
All PTO/PTS shall be manually captured after the interruption. The distributor licensee shall ensure that the dates and supply on and off times are accurately and reliability captured. These records are to be made available to be audited on request by the affected customer or the NERSA. The distributor licensee shall implement an appropriate monthly validation process of all PTO/PTS issued.

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

7.6 Data validation of events
The process of validating the data for network events depends on the event type. The event can either be unplanned interruptions or planned work.

7.6.1 Unplanned interruptions
These types of events are characterised by switching operations triggered by protection equipment and frequently by equipment failure. The licensee must 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 must determine that the switching sequence is valid and practically possible for the customers affected and the network configuration. The number of customers affected and the MVA.Hours lost, need to be analysed accurately. The location, operation type and cause descriptions must be relevant to the event and associated network operations.

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

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

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

Manual tracing implies that a user must manually determine which transformers and customers were affected and the durations that these loads and customers were affected for. This requires a user to examine all available information to validate an event.

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

7.6.4 Transformers affected
All transformers must be recorded where supply to the network was affected. The user must by examining the affect of the network operations on the network, determine the transformers and customers that were affected by the interruption of supply.

The following applications as specified in Annex C shall be implemented by the distributor licensee:

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

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.

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

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

8 Interruption cause code categories

8.1 Overview of categories
This section presents a minimal set of data codes and a consistent categorisation structure necessary for interruption cause code collection, reporting and the comparison of distribution network performance in South Africa. There are 12 primary cause codes and 6 secondary cause codes. The primary cause codes provide high level information about the nature of the cause of interruption while the secondary codes provide additional information about the location, condition and circumstances of the cause.

The primary cause codes (A category) are characterised by the following:

A.1 Conductor and structure
A.2 Equipment (including secondary/control plant)
A.3 Planned work
A.4 Operational causes
A.5 Supply intake
A.6 Vegetation
A.7 Weather (including lightning)
A.8 Wildlife
A.9 Customer
A.10 Third party caused (including vandalism)
A.11 Other (not covered in the pre-defined cause categories)
A.12 Unknown (the cause of the interruption is unknown)

The secondary cause codes are characterised by the following:
B: Responsible system
C: Conditions
D: Voltage
E: Interrupting devices
F: Interruption device initiation
G: Interruption disconnected method

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 categorise the causes of interruptions into logical and systematic categories to assist with identification of potential problems areas and the application of mitigation projects or improvement initiatives.

Note 2: Broad categories were intentionally established to help minimize data collection efforts by the distributor 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 (other 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 distributor licensees.

8.2 Description of sub-cause code categories

The following information below describes the type of interruption cause codes and sub-codes that shall be selected by the distributor licensees.

8.2.1 A: Primary sub cause code categories

A.1 Conductor and structure
Any component of the overhead line or underground cable system that is defective or fails and causes an interruption to customers should be selected under this category. The following is the list of sub-codes to be used:
A.1.1: Cable conductor
A.1.2: Cable joints/splices (including the ferrules)
A.1.3: Cable terminations (including the lugs)
A.1.4: Overhead conductor
A.1.5: Connector
A.1.6: Insulation
A.1.7: Structural support

The cable category includes all cable wire that is directly buried or encased in pipe or conduit, including ends.

The conductor category refers to overhead strung wire and the wire jumpers.

The connector category includes connectors, insulinks, splices, connections and other related connection hardware.

The category insulation is comprised of bushings, insulators, separable connectors, polymeric terminations, potheads and stress relief cones.
The category structural support includes the anchors, poles, towers, woodpole structures, cross arms, and braces.

A.2 : Equipment
Any item of plant of the distribution system equipment that is defective or fails and causes an interruption to customers should be selected under this category. The following is the list of sub-codes to be used:
   A.2.1 : Control and protection
   A.2.2 : SCADA
   A.2.3 : Circuit breaker
   A.2.4 : Recloser
   A.2.5 : Fused equipment
   A.2.6 : Surge Arrester
   A.2.7 : Switch
   A.2.8 : Transformer

The Control and protection category contains relays, meters, and other control equipment that has failed.

The SCADA refers to the SCADA system.

The circuit breaker, recloser, and fused equipment categories are self-explanatory.

The surge arrester category is self-explanatory.

The switch category contains disconnect or isolation, load break and cutouts.

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

A.3 : Planned work
The planned work category includes all interruptions that are routine or pre-arranged as defined in section 5.3.
   A.3.1 : Routine
   A.3.2 : Pre-arranged
   A.3.3 : Customer requested

A.4 : Operational causes
The operations error category includes any interruptions that were caused by the distributor licensee's staff while operating the network. This category includes incorrect protection settings.
   A.4.1 : Incorrect protection operation
   A.4.2 : Incorrect control equipment operation
   A.4.3 : Operator error
   A.4.4 : Emergency

A.5 : Supply intake (non-distributor licensee caused)
The supply intake category includes interruptions as defined in section 5.5 that are not caused by the distributor licensee. These interruptions are caused by a failure in the transmission system including the transmission portion of a substation or the loss of a generating unit in a power station or by nearby embedded generation or by nearby other distributor licensees.
   A.5.1 : Loss of supply due to technical problem
   A.5.2 : Loss of supply due to non-payment
   A.5.3 : other
A.6 : Vegetation
The vegetation category includes interruptions caused by falling trees and growth of trees 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 may not be possible to determine that a network may have a forestry issue if wind is listed as the cause when actually a tree was involved.
A.6.1 : Tree growth in servitude
A.6.2 : Trees falling onto the line

A.7 : Weather
The category of weather should include interruptions due directly to a weather phenomenon including wind, snow, ice, hail and rain, where the weather itself caused the interruption. Ice forming on conductors and then the conductors falling down causing an interruption or flooding causing woodpole structures to collapse, shall be included in the weather category.
A.7.1 : Lightning
A.7.2 : Wind
A.7.3 : Rain/hail/flooding
A.7.4 : Snow/ice
A.7.5 : Sugar cane fires
A.7.6 : Veld/bush fire
A.7.7 : Earthquake
A.7.8 : Tornadoes
A.7.9 : Heatwave/high temperatures

A.8 : Wildlife
A.8.1 : Birds
A.8.2 : Monkeys/baboons
A.8.3 : Reptiles/snakes
A.8.4 : Ants/insects

A.9 : Customer
Any interruptions caused directly by the customer or their appointed agents
A.9.1 : Customer caused
A.9.2 : Appointed agent or contractors
A.9.3 : Customer’s protection failed to clear a fault, etc.

A.10 : Third party
A.10.1 : Motor vehicle accidents
A.10.2 : Theft
A.10.3 : Human interference (unrelated to the operation or maintenance of the network)

A.11 : Other
Any interruptions that do not fall into any of the above primary cause code categories should be assigned to the other category. The distributor licensee shall provide a brief description of each interruption assigned to the other category.

A.12 : Unknown
The unknown category includes any interruptions where a definitive cause cannot be determined even after a formal investigation. The distributor licensee shall provide a brief description of each interruption assigned to the other category.
8.2.2 Secondary sub cause code categories

B : Responsible system
The responsible system is defined as the portion of the system that initiated the interruption of supply. There are several responsible system categories. These include the following:

B.1 : Distribution overhead
B.2 : Distribution underground
B.3 : Generation
B.4 : Distribution substation
B.5 : Intake supply
B.6 : Distributed generation
B.7 : Customer equipment

The first six categories above are easy to understand and no further discussion is included for those categories. The customer equipment category refers to customer owned equipment that is an integral portion of the distributor licensee’s system and when an interruption occurs on the customer owned equipment, causes interruptions to one or more of the licensee’s other customers.

C : Conditions
The categories under conditions refer to conditions at the time of the interruption. Many times the condition may be a contributing factor to the number of interruptions experienced or the time it takes to restore supply back to the affected customers. The conditions may play an important role when analysing the interruption cause code data. The condition categories include:

C.1 : Normal
C.2 : Minor event
C.3 : Major event

Normal is blue sky day or typical daily operating conditions. A minor event condition is a small weather disturbance that is not large enough to be classified as a major event. A major event is an event as defined in section 5.2.3 that meets the number of customers affected or MVA.Hors lost criteria.

D : Voltage
The voltage information due to an interruption event should be based on the voltage level where the interruption was initiated. The voltage categories shall include:

D.1 : Low voltage (LV)
D.2 : SWER
D.3 : 11kV or 22kV
D.4 : 33kV
D.5 : High voltage (HV)
D.6 : Extra high voltage (EHV)
D.7 : HVDC

Note: Some distributor licensees may decide to treat 33kV networks as HV network category based on their specific application in their area of supply.

E : Interrupting devices
The following shall be the list of categories of interrupting devices to be selected from:

E.1.2 : Circuit Breaker
E.1.3 : Recloser
E.1.4 : Fuse
E.1.4 : Line recloser
E.1.5 : Sectionaliser
E.1.6 : Switch
E.1.7 : Other

E.2 : Did the correct (normally nearest upstream device) operate to clear the fault?
   E.2.1 : Yes
   E.2.2 : No

E.3 : Did the network auto reclose appropriately?
   E.3.1 : Yes
   E.3.2 : No

Note: Benchmarking studies may review the type of interrupting devices used, their failure rates, how many operations occurred and the total number of devices deployed.

The circuit breaker/recloser category shall include circuit breakers and reclosers found in substations and those used for protection of networks. The fuse category shall include line, tap, and transformer fuses.

Reclosers located along a line should be in the line recloser category. All load and non-load breaking switches are captured in the switch category. Any other interrupting devices not covered by the first five categories are grouped under the other category.

F : Interrupting device initiation
The interrupting device category shall include the manner in which they operated when they were opened and closed. These operations can fall into the following two categories:
   F.1 Automatic
   F.2 Manual

Automatic includes all operations without human intervention or those operations made automatically. Manual is any operation that involves personnel to operate the device, whether at the location of the device or from a remote location.

G : Interruption restoration method
There may be several ways to restore supply to customers after an interruption. The interruption restoration categories are as follows:
   G.1 : Automatic substation transfer
   G.2 : Manual substation transfer
   G.3 : Automatic circuit sectionalizing
   G.4 : Manual circuit sectionalizing
   G.5 : Left disconnected?
   G.6 : Re-energized at substation
   G.7 : Repaired defective equipment
   G.8 : Replaced defective equipment
   G.9 : Replaced fuse
   G.10 : Reset transformer breaker
   G.11 : Switch customer on

The category automatic substation transfer includes any scheme that transfers customers to an alternate supply in the event that their primary supply is interrupted. This scheme operates without any human intervention.
The automatic circuit sectionalizing category, refers to any automatic scheme outside the substation that transfers customers experiencing an interruption to another energized network segment, either on the same network or a different network.

The manual circuit sectionalizing category, refers to any action taken by field personnel or remote operation by the network control centre, to facilitate restoration after separating them from the faulty network transfer interrupted customers to other networks. This also includes the resetting of midline reclosers and operating switches to re-energize interrupted customers to another part of the same network.

In some cases, customers will not ever be put back in service due to fire, flood, or some other destructive force that destroys the customer requiring the supply restoration. In this case, the category left disconnected is to be used.

Sometimes a network is locked out at the substation and no cause is found. The circuit breaker or recloser is closed again (reclosed), and if it holds, the category re-ENERGIZED at substation is chosen. This category may also be used for a transformer or bus interruption in the substation.

The last four categories repaired defective equipment, replaced defective equipment, replaced fuse and reset transformer breaker are self-explanatory.

9 Data Management

Future regulatory requirements may require different forms of historical data to be accessed. It is a requirement that interruption performance data be managed at a minimum according to the levels described below.

9.1 Data archiving

Interruption performance data for reporting shall be retained for a minimum of five (5) years in a format that allows for:
   a) Retrieval by network, substation, district/area and total system
   b) Retrieval of the raw event data details and cause codes per event per network per day

A detailed record of software or system related changes to the data reporting shall be kept, including:
   a) The nature and impact of the change
   b) The date from which the change was implemented
   c) The business reasons for the change
   d) A demonstration of the “before” and “after” impact of the data change with at least 12 months of data used to illustrate the impact

The intention is for the distributor licensee to be able to confidently 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 of a distributor licensee)

9.2 Accuracy guidelines of the interruptions reporting

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

The distributor 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. It is a requirement that both the accuracy levels for the number of customers interrupted and the duration of interruptions of supply, are met by the licensee.

The distributor licensee is to 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 distributor licensee shall be required to have the customer network link greater than or equal to 95% in the reporting period.

Note 1: It is proposed that the licensee conducts a self audit initially, but this may become a future regulatory requirement. The reporting accuracy levels will be critical once IBR is implemented.

Note 2: 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 are introduced in the future.

9.3 Estimating methodology for the annual accuracy of the interruptions reporting

There is a concern that the interruption durations can be manipulated by distributor licenses in order to artificially create particular type of networks events 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.

9.3.1 Step 1
The NERSA may appoint external auditors to conduct the accuracy of interruption performance reporting audit by distributor 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. 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.

9.3.2 Step 2
The auditors are to 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/number of customers affected and the audited interruption restoration time/number of customers affected. The auditors will then calculate the mean, standard deviation and the mean plus/minus 4 standard deviations of the errors. The auditors are to exclude any of the events containing outlier interruption restoration times or number of customers affected (where the error calculated is outside the mean plus/minus 4 standard deviations).

9.3.3 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 formula below. The outlier events are excluded.

Reporting Duration Accuracy % = \[
\frac{\text{Sum of reported interruption of supply durations}}{\text{Sum of audited interruption of supply durations}} \times 100
\]

(17)

Reporting Customer Number Accuracy % = \[
\frac{\text{Sum of reported customer numbers affected}}{\text{Sum of audited customer numbers affected}} \times 100
\]

(18)
9.3.5 Step 4
If the network interruption performance reporting accuracy is $\geq 95\%$, 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 levels will be adjusted to reflect a 100% accuracy level. This means that the interruption restoration time based indices and number of customer affected indices may be adjusted to reflect a 95% level of accuracy.

The distributor 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. It is a requirement that both the accuracy levels for the number of customers interrupted and the duration of interruptions of supply, are met by the licensee.

10 Network interruption performance reporting requirements

10.1 Annual power quality reporting requirements

The following network interruption performance information shall be reported by the distributor licensee as part of the annual power quality (PQ) report to NERSA:

- a) SAIFI
- b) CAIFI
- c) SAIDI
- d) CAIDI
- e) MSLI
- f) HSLI
- g) Interruptions/100km (overhead and underground networks reported separately)
- h) MAIFI
- i) MAIFIe
- j) MInterruptions/100km (overhead and underground networks reported separately)
- k) Worst served customers
- m) Customer supply restoration times
- n) Number of major events occurring, the impact of the major event on the indices and the supply received by the affected customers in a geographical area and the comprehensive investigation report dealing with the cause of each major event
- o) Voluntary load reduction events

Note: The system level performance reported needs to be the customer weighted average of the relevant districts or areas.

The above reported interruption performance indices shall be reported separately as per the following categories:

- a) Unplanned interruptions
- b) Planned interruptions
- c) Overall performance (unplanned, planned components and HV and MV combined)
- d) HV (where applicable)
- e) MV (where applicable)
- f) 33Kv (where applicable)
- g) Major events as per category A
10.1.1 Categories for exclusion
The following shall be excluded from interruption performance indices, but the relevant information reported about these categories separately:

a) Customer related
b) Intake supply related
c) Major events
d) Voluntary load reduction events
e) Customer interruptions of supply due to voluntary load reduction events
f) Single phasing events

10.1.2 Customer numbers reporting
The distributor licensee will be required to report the total number of customers as defined by the total number of customers whose electricity supplies are connected to the Distributors network as at in the relevant reporting year, with its annual interruption performance submission. The customer count methodology needs to be clearly defined and explained by the distributor licensee to NERSA.

Note: NERSA needs to define the 12 month period with appropriate with start and end dates.

10.1.3 Total length of network
The licensees shall provide the NERSA with the following network length:

a) Total length of overhead circuit km per voltage level
b) Total length of underground cable per voltage level
c) ABC aerial bundle conductor per voltage level (i.e. LV and MV)

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

10.1.4 Sum of installed transformer capacity
The licensees shall provide the NERSA with the following transformer capacity:

a) Total number of transformers for HV/MV and MV/LV
b) Sum of the transformer capacity in MVA for HV/MV and MV/LV (transformer name plate information to be used)

The above excludes all coupling transformers. Transformers shall be grouped according to their primary voltage, and nominal ratings shall be used to calculate installed capacity. For each voltage level, the sum of the two asset categories above should be equal to the total network length for each voltage level.

10.1.5 Areas of distribution reporting
The licensees shall provide the NERSA with a separate return for each logical area of electricity distribution within their licensed areas of supply. For example, Eskom Distribution would submit a separate return for each of its six distribution regions. A metropolitan area with four substructures, would provide a separate return for each substructure. Where there is any doubt as to what constitutes a logical area of supply, the NERSA should be consulted for a ruling. A licensee shall advise the NERSA of any planned changes in the demarcation of logical areas of distribution.

Each return shall provide the information as set out in 4.7.2.2 and 4.7.2.3.

10.1.6 Technical commentary and cause codes
The following additional key information is also required to be reported:

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
b) The interruptions experienced per primary (A) and secondary (B to G) cause code with a high level pareto analysis and technical commentary.

10.2 Reporting for incentive based purposes

The NERSA will determine, in consultation with the distributor licensees, which network interruption performance indices are to be used in the incentive based regulation. The following shall be excluded from the interruption performance indices reported:

a) Major events (reported individually)
b) Intake supply related events
c) Customer related events
d) Voluntary load reduction cause interruptions

The planned work and unplanned interruption indices shall be reported separately to encourage the correct behaviour of the licences in managing the network faults and planned work program. The reporting period will be based on the financial year.

10.3 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 practices), but also of the measurement and reporting methods used. NERSA to establish in consultation with licenses and the benchmark company and peer group.

The following shall be excluded from the interruption performance indices reported for benchmarking:

a) Major events (reported individually)
b) Intake supply related events
c) Customer related events
d) Voluntary load related events

The planned work and unplanned interruption indices shall be reported separately

11 Implementation of the standard

This standard provides the framework for the future requirements of network interruption performance measurement and reporting in South Africa. It is recognized that present systems of the distributor licenses do not meet the minimum requirements specified in this standard and that there are also resource constraints.

It is recognised that not all distributor licenses will have full SCADA coverage compile a detailed business plan to be implemented in phases starting with HV sub stations and key MV substations supplying areas with large number of customers. It is recommended that the initial implementation will require a phased in approach (3-5 years) and that NERSA will specify the timeframe and compliance level for such implementation, in consultation with the various Distribution industry stakeholders. The smaller distributor licenses would be required to implement the key principles and concepts even if on a paper based or simple software spreadsheet system.

It is also recommended that NERSA establishes an industry working group of all the relevant role-players to ensure common understanding of the key principles, provide a forum for the discussion of;
Annex A
(informative)

Recommended user interface functionality and report scheduling procedures

A.1 User interface functionality
The user interface functionality should allow for:

a) The various reports to be formatted differently such as basic static html or active applet formats.

b) The exporting of data interactively to a specified spreadsheet program, allowing the user to manipulate the format of the report and produce various graphic presentations (such as bar, pie and line graphs).

c) Allow for a full windowing environment, capable of concurrently displaying multiple windows of information.

d) Allow for interactive procedures to be included to guide the user through the proper steps with some form of displayed acknowledgement at every step of the operation.

e) Provide accurate tracking and an auditable process of all user actions that can influence the state of the actual network, that impact on the network interruption performance indices or in any manner impact on the safe operation of the network.

f) Provide error messages explaining why a user action was rejected. The error messages shall be displayed in plain language (i.e. no cryptic or coded messages shall be used).

g) Provide user configurability such as colouring, textual descriptions and sizing,

A.2 Report scheduling
The report scheduling functionality and procedures should allow for:

a) The reports to be calculated and generated on demand, or scheduled to run at specific times of the day or week. This will require configuration of jobs and development of scripts to run certain standard reports.

Note: The system performance impact needs to be carefully considered in configuring the frequency, type, and number of scheduled reports to be run.

b) The standard Information Storage and Retrieval (IS&R) module to be used as the basis to support this functionality. This module archives network interruption related data periodically to an off-line database. The process shall be triggered based on a user defined interval of time.
Annex B
(informative)

Manual and automatic interruption performance reporting systems

B.1 Manual data collection systems

A distributor licensee with only paper maps and little or no accurate data connectivity will utilise the manual data collection approach. The staff of the licensee estimate the number of the customers affected during a supply interruption. The distributor licensee’s couple these affected customer estimates with an estimate of the start time of the interruption to determine the impact of each network event on the customers. Focus tends to be placed on areas of the network that have poor reliability or poor customer satisfaction.

Without a fully connected data model that provides the connectivity of each customer to the protective devices upstream on the network, the distributor licensee call centre or control centre staff have to manually group individual customer calls by area and then provide this information to field personnel for supply restoration. Using this approach will often result in customers on different devices being grouped together inappropriately thereby unnecessarily extending the restoration time. In this case, the field personnel have to contact each customer to make sure that all the affected customers had supply restored with the single restoration or assume everyone in the area had supply restored. This can result in some customers having to again call back to log in their continued supply interruption.

With the manual data collection system, the estimates from the licensee staff tend to vary greatly and are based solely on the field workers best guess. This estimate can be made as conservative as desired to provide an overly optimistic result or a pessimistic to justify desired increase in funding for projects to improve the performance. This type of approach only provides general reliability trends and should be used by the distributor licensee for internal comparison and not used to benchmark reliability levels with other distributor licensee’s unless the results are clearly marked as generated with a manual system.

The interruption records are manually entered into a spreadsheet or database and are maintained as time allows by existing personnel with varying degree of timeliness and competency. Most of these systems allow for free-form text entry thereby introducing errors into the system merely from the act of imputing the interruption data. The level of detailed information captured for each interruption will be limited and may not always include such information as the cause of the interruption, the device affected, the location of the interruption and a variety of other useful types of information required by the distributor licensee.

B.2 Fully automated data collection systems

There are those distributor licensee’s that have a full data connectivity model from customers to transformers, to network protective devices and finally back to substation protective devices (e.g., breakers). These systems can use OMS that may be based on a complete GIS and in some cases it may include information provided by a real time substation device interruption reporting system via SCADA. With this fully integrated system, the distributor licensee has the potential to have an accurate count of the number of customers affected by each interruption as well as the duration of each interruption of supply.

Distributor licensee’s must implement change management to insure that all the key personnel are properly operating all the new information systems and understand the impact of their actions on the end product (the network interruption performance indices).

Using such fully automated systems allows for the provision of timely results of network interruption performance indices and reliability trending. Analysis may be performed down to specific device level or sections of the network. With the full customer connectivity model, the distributor licensee not only will have more accurate information to build their reliability statistics, but they will have the ability to group individual customer interruptions to specific transformers or fused spur lines and minimize the number of equipment interruptions being investigated at one time.
Most distributor licensee’s that have implemented a more accurate and sophisticated data connectivity model and interruption management system have found that their reliability statistics appear to have deteriorated (trend up appearing worse off). In many cases, the new sophisticated systems allow for full accounting of the number of customers affected by each network event. The interruption durations have more accurate start and end times for the interruptions are captured. This should not be considered a reason not to implement such a system; rather the more accurate methods will provide many capabilities for the distributor licensee to develop a better picture of problem areas and the comparable magnitude of the problems for prioritisation action. These systems will help the distributor licensee optimize their financial spending and assist in meeting the challenges of the increasing regulatory scrutiny and target setting.

B.3 Implementation of fully automated systems

The current technologies, systems and processes used by different distributor licensee’s around the world are based on many different drivers that are distributor licensee specific and are the result of many years of operation and development. In the 1990’s, it was good enough in most cases, to operate based on a manual system and report on estimated network interruption performance levels. As more electricity regulators and customers demanded better data and information on supply interruptions, distributor licensee’s have elected to implement more advanced systems with better underlying data connectivity models. Many of these systems were expensive and took years to implement. No matter the reason for improvements in the components of the company’s interruption management process, the distributor licensee can build on these advancements to provide improved accuracy and response time.

All interruption management processes rely on several key components such as:

1. Connectivity model from customer to substation
2. A tabular listing of transformers and devices to customers
3. A full GIS model
4. Customer Interruption Reporting form
5. Customer service representative contact (live person)
6. SCADA
7. Distribution automation devices
8. Automatic meter reading interruption reporting
9. Interruption reporting devices installed in the customer system
10. Call Analysis or grouping capabilities
11. Event tracking and recording at customer and/or device level via hard copy, electronic database, mobile data terminals and manual network event entry

All of the above key components of an interruption management system can be provided in many different ways with varying levels of completeness and accuracy.

For those distributor licensee’s that do not currently have or cannot financially justify the purchase and implementation of an electronic GIS, establishment of the data connectivity model by itself may be justified based on the interruption call grouping functionality that can improve the efficiency of the dispatch personnel and reduce interruption restoration times.

Gathering the interruption information in a timely manner is key and even the most sophisticated, fully-computerized OMS can only analyse and group the customer interruptions entered into the system. If there is a limit in the number of customer calls that the telephone representatives can enter in a given period, the OMS may not reduce the number of work orders for dispatching. Distributor licensees with limited network event reporting capabilities may easily be able to cost justify funding for increased number of phone representatives or implement an IVR system.

As distributor licensee’s improve the data connectivity model and interruption reporting methods, more emphasis can be made to justify expanding the OMS capabilities.
The OMS can either be developed in-house by the distributor licensee or obtained from one of the OMS providers currently on the market that best utilise the distributor licensee’s existing data connectivity model and interruption reporting processes.

Purchasing a packaged OMS will probably provide the distributor licensee with “bells and whistles” capabilities that have not even been considered, but as a package, can be incorporated into the cost justification for the purchasing of the product.

As each distributor licensee deals with the key components they need to consider the overall importance of each function to the distributor licensee and focus funding to any of the components that will limit the process below that which the distributor licensee needs for their overall operations and the customer reliability.
Annex C
(informative)

Example of network interruption performance index calculations

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.

C.1 Introduction of the scenario

The field services department of a distributor licensee is doing planned maintenance by replacing the insulators on the network spur (section of line) from the SR136/1 links (refer below to the line diagram). With the following given network diagram and operation, the network interruption performance calculation method is explained below.

LEGEND

- = 500kVA Transformer
- = 22kV MV Breaker
- = 132kV HV Breaker
- = Pull Stick/Fuse Links

Cust. Stands for customers
Table C.1 Network operating/switching report

<table>
<thead>
<tr>
<th>Sub / Overhead Line</th>
<th>Equipment</th>
<th>Operation / Cause</th>
<th>Date</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCENA 22KV S/S SF Line</td>
<td>Line section SR136/1 to END -- SR Line WO: ( 8010192135 )</td>
<td>Schedule Outage - Planned Maintenance - Replace insulators</td>
<td>2005/02/14</td>
<td>08:00:00</td>
</tr>
<tr>
<td></td>
<td>Breaker 22 [kV] SR1 -- SR Line</td>
<td>Brkr Opened</td>
<td>2005/02/14</td>
<td>08:05:00</td>
</tr>
<tr>
<td></td>
<td>Isolator 22 [kV] SR136/1 -- SR Line</td>
<td>Links Opened</td>
<td>2005/02/14</td>
<td>08:10:00</td>
</tr>
<tr>
<td></td>
<td>Breaker 22 [kV] SR1 -- SR Line</td>
<td>Brkr Closed</td>
<td>2005/02/14</td>
<td>10:50:00</td>
</tr>
<tr>
<td></td>
<td>Isolator 22 [kV] SR136/1 -- SR Line</td>
<td>Links Closed</td>
<td>2005/02/14</td>
<td>10:55:00</td>
</tr>
<tr>
<td></td>
<td>Breaker 22 [kV] SR1 -- SR Line</td>
<td>Brkr Closed</td>
<td>2005/02/14</td>
<td>11:00:00</td>
</tr>
</tbody>
</table>

C.2 Explanation of network operation

At 08:00 the main breaker opened and 1200 customers were affected and 5 minutes later the links were opened at SR136/1. At 08:10 the main breaker was closed, but 300 customers beyond the SR136/1 links where still without supply. At 10:50 the main breaker opened and all 1200 customer were without supply, 900 customers for the second time while the 300 from SR136/1 not noticing this operation. At 10:55 the links were closed without affecting any customers. Only at 11h00 the main breaker was closed and supply was restored to all 1200 customers.

C.3 Calculations of network interruption performance due to planned work

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

C.3.1 SAIFI calculation

From the above operation sequence there is a group of customers affected differently from the other group of customers. The 300 customers from SR136/1 to END experienced only 1 (one) interruption, from 08h00 when the main breaker SR1 opened until the breaker was closed at 11h00. The other 900 customers on the network were interrupted twice, once from 08h00 to 08h10 and a second time from 10h50 to 11h00. If only this one event occurred for the month, the SAIFI for the network would be calculated as below:

\[
SAIFI = \frac{(900 \times 2) + (300 \times 1)}{1200} = 1.75
\]

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

On average, the customers on network experienced 1.75 interruptions (some two interruptions and some only 1 interruption). The average is more towards 2 than 1, because more customers experienced the two interruptions.

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 it as one sustained interruption from 08h00 to 11h00 affecting 1200 customers.
The SAIFI will be calculated as below:
\[
SAIFI = \frac{(1200 \times 1)}{1200} = 1
\]

From the above, it is clear that the interruptions created by isolating the work area from the rest of the network will not affect the SAIFI calculation negatively. However, the least amount of customers needs to be affected during the pre-arranged outage from start to finish, as the numerator determines the weighting 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:
\[
SAIFI = \frac{(300 \times 1)}{1200} = 0.25
\]

**C.3.2 SAIDI calculation**

From a duration point of view, 900 customers experienced two 10 minute interruptions and 300 customers experienced a 3 hour interruption. SAIDI for the network effectively calculates the average duration that the 1200 customers on the network experienced. The measurement units are in hours, so 10 minutes equals 0.167 hours in the calculation below.
\[
SAIDI = \frac{(900 \times 0.167) + (300 \times 3) + (900 \times 0.167)}{1200} = 1
\]

On average the 1200 customers were affected for 1 hour. The bulk of the customers (900) experienced 20 minutes total duration during the planned outage and the smaller group of customers, experienced the long outage duration of 3 hours. This explains why the average duration tends towards 20 minutes.

With the pre-arranged event criteria considered, the interruptions would be considered as a single interruption lasting 3 hours for the customers affected by the pre-arranged planned interruption (which are the 1200 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 below:
\[
SAIDI = \frac{(1200 \times 3)}{1200} = 3
\]

From the above example, it can be seen that the isolation of the 300 customers before work started did not benefit the SAIDI figure. The least amount of customers needs to be affected from the start of the interruption up to the end of the pre-arranged event. If there was a current breaking device on section SR136/1, only 300 customers would have been affected. The SAIDI for the network would then have been:
\[
SAIDI = \frac{(300 \times 3)}{1200} = 0.75
\]

**C.3.3 CAIDI calculation**

CAIDI calculates the average duration per interruption, which is equal to the average total duration divided by the average customer interruptions.
Note that the denominator of SAIDI and SAIFI effectively becomes a division by 1, thus the CAIDI can be written as the numerator of SAIDI divided by the numerator of SAIFI. It thus took 0.57 hours per interruption to restore power to each customer.

With the pre-arranged event criteria however 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.

\[
CAIDI = \frac{SAIDI}{SAIFI} = \frac{(900 \times 0.167) + (300 \times 3) + (900 \times 0.167)}{(900 \times 2) + (300 \times 1)}/1200
\]

\[
CAIDI = \frac{900 \times 0.167 + (300 \times 3) + (900 \times 0.167)}{(900 \times 2) + (300 \times 1)} = 0.57
\]

Note that the 1200 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 hours.

C.3.4 MSLI calculation
The MSLI is calculated in a similar manner as the SAIDI, but with the customer number figure being replaced with the MV installed capacity figure. This time 4 MVA was affected for 10 minutes on two occasions and 1.5 MVA was affected for 3 hours.

\[
MSLI = \frac{(4 \times 0.167) + (1.5 \times 3) + (4 \times 0.167)}{5.5} = 1.06
\]

This means that the total MV installed capacity was without supply for an average duration of 1.06 hours.

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 a MSLI being calculated as below:

\[
MSLI = \frac{5.5 \times 3}{5.5} = 3
\]

If a current breaking device was use to isolate section 136/1, only the 1.5MVA would have been affected. This would have resulted in a MSLI as below:

\[
MSLI = \frac{1.5 \times 3}{5.5} = 0.82
\]
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.

C.3.5 HSLI calculation
In the above scenario, no HV equipment was affected by the interruptions, therefore the HSLI is zero.

\[
DSLI = \frac{0}{20} = 0
\]
Annex D
(informative)

Transformer loss definitions for different winding configurations due to interruptions

D.1 Two-winding transformer

D.2 Three-winding transformer

D.3 HV power transformer
D.4 Coupling transformer

Coupling trfr no loss

Coupling trfr’s no loss