Operating Security Standards

December 2011

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Contents

1 OBJECTIVE

The objective of the Operating Security Standards is to present a concise definition of such standards on which operating procedures may be based.

2 SCOPE

The Operating Security Standards shall apply to:

- TSO;
- **External System Operator**, in respect of system frequency and **Tie-Line** operation only.

The Operating Security Standards reflect the requirements of the Transmission Planning Standards, Grid Code and the annual Transmission Performance Report to the CER.

3 CRITERIA

3.1 General

- The TSO shall at all times aim to operate the **transmission system** in accordance with the criteria stated in this Operating Security Standards. However it may be necessary to operate the system outside of the stated Operating Security Standards to avoid unacceptable or unsafe operating conditions for the transmission system, transmission **plant** or personnel or as provided for in the Grid Code or in the **Power System Restoration Plan**

3.2 Security criteria

The **transmission system** shall be operated such that under normal conditions[1] and in the event of the following contingencies:

- **N-1**, covering the loss of any single item of generation or transmission **plant** at any time;
- **N-G-1**, an overlapping single **contingency** and **generator outage**;
- **N-1-1**[2], an overlapping **contingency** in which the forced outage of a transmission or generating element occurs while another element is out on a scheduled system **outage** (trip-maintenance event) and;
- **loss of the largest single power in-feed**

[1] As defined in the Grid Code
[2] During transmission maintenance season, there are typically multiple simultaneous outages

There shall not be any of the following:

- loss of supply except as in Table 3-1;
- **unacceptable frequency conditions** (outside the limits in Table 3-2);
- **unacceptable voltage conditions** (outside the limits in Table 3-3 and in Table 3-4);
- **unacceptable overloading** of any transmission **plant which cannot be solved within an acceptable timeframe by generation re-dispatch or appropriate remedial action schemes** (outside the limits in Table 3-5) or;
- **system instability**

Table 3-1 – Maximum permitted loss of supply following contingencies

Transmission Station Configuration	**N-1 Contingency**	**N-1-1 Contingency (trip/maintenance) & / or N-G-1**
110kV Station (or a series of connected stations) normally fed via two 110kV lines connected	None	All load tail fed as a result of a maintenance **outage** of one of the 110kV lines. In accordance with the planning criteria the total load should not normally exceed 80MW of load[3]
Any station **tail fed** as a result of **pre - contingency** sectionalising	No load that is not normally tail fed[4]	Load[3], which is not greater than 3% of **system demand**, that is not normally **tail fed**[4]
110 kV **Tees**	All load connected to the **tee**	N/A

3.3 System frequency

3.3.1 System frequency ranges

The system shall operate within the frequency ranges outlined in Table 3-2. The TSO may implement measures to ensure the frequency ranges are respected by taking appropriate actions such as providing additional reserve as may be required when, for example, the mix of sources of power in-feeds varies[5] and system response/inertia is as a consequence varied.

[3] Load in this case refers to all load other than directly connected customer load i.e. distribution load
[4] Normally **tail fed** means that the station was designed in accordance with the planning criteria to be **tail fed**
[5] Such variation of the mix of the source of power in-feeds shall take account of power in-feeds from conventional synchronous generation, wind farm power stations (having low inertia) and converter in-feeds (have no inertia), including HVDC

Table 3-2 - System Frequency Ranges

Description	Range
Normal operating range[6]	49.8 to 50.2 Hz
During **Transmission System** disturbances	48.2 to 52.0 Hz
During exceptional **Transmission System** disturbances, not exceeding 60 minutes duration for frequency in the range 47.5 to 49.8 Hz and 50.2 to 52.0 Hz and not exceeding 20 seconds for frequency in the range 47.0 Hz to 47.5 Hz.	47.0 to 52.0 Hz
Maximum rate of change of frequency	0.5 Hz per second

The transmission system shall be operated such that the frequency can recover to 49.5 Hz within one minute of the **loss of the largest single power in-feed**.

3.3.2 Time error

Time error shall not in normal circumstances exceed ± 10 seconds.

3.4 Demand control

The TSO shall implement such measures of **demand control** (customer **demand reduction**/reconnection), automatic low frequency or voltage **demand disconnection** and restoration as it deems appropriate and as are in accordance with the Grid Code.

3.5 Power system restoration

The EirGrid **Power System Restoration Plan** provides a plan of action to be implemented after a total power system blackout has occurred. EirGrid will maintain this plan and both revise and test it every two years.

3.6 Reserve

Reserve shall be maintained in line with the System Operator Agreement and as may be published on the EirGrid web site from time to time.

[6] Frequency target is set to 49.95 or 50.05 Hz to correct time error

EirGrid must ensure that sufficient additional generation output, or demand relief, is scheduled in order to maintain supply to customers in the event of rapid loss of a largest generation in-feed. This can be termed as "**Operating Reserve**".

EirGrid **Operating Reserve** definitions are as follows:

a) Primary Operating Reserve (POR): The additional **MW output** (or reduction in **demand**) at the frequency nadir compared to the pre-Incident output (or **demand**), where the nadir occurs between 5 and 15 seconds after the event. If the actual frequency, nadir is before 5 seconds or after 15 seconds after the event, then for the purposes of POR monitoring the nadir is deemed to be the lowest frequency which did occur between 5 and 15 seconds after the event.
b) Secondary Operating Reserve (SOR): The additional **MW output** (or reduction in **demand**) compared to the pre-incident output (or **demand**), which is fully available and sustainable over the period 15 to 90 seconds following the event.
c) Tertiary Operating Reserve 1 (TOR1): The additional **MW output** (or reduction in **demand**) compared to the pre-incident output (or **demand**), which is fully available and sustainable over the period 90 to 300 seconds following the event.
d) Tertiary Operating Reserve 2 (TOR2): The additional **MW output** (or reduction in **demand**) compared to the pre-incident output (or **demand**), which is fully available and sustainable over the period 300 to 1200 seconds following the event.
e) Replacement Reserve: The additional **MW output** (and/or reduction in **demand**) required compared to the pre-incident output (or **demand**) which is fully available and sustainable over the period from 20 minutes to 4 hours following an event. The purpose of this category of reserve is to restore primary reserve within 20 minutes including restoring any interruptible load shed.

3.7 Fuel dependency

The TSO shall regularly test the secondary fuel capability (including switchover and stock levels) of a thermal generating plant in accordance with the provisions as set out under their Secondary Fuelling Obligations[7]. EirGrid may from time to time, should conditions require it based on the status of the electricity and/or gas transmission networks, limit the total amount of power produced by a single fuel.

3.8 Voltage

3.8.1 Voltage ranges

The system shall operate within the voltage ranges outlined in Table 3-3[8]

[7] CER/09/001, Decision Paper; Secondary Fuel Obligations on Licensed Generation Capacity in the Republic of Ireland, 7th January 2009
[8] Subject to existing Grid Code derogations

Table 3-3 - Voltage Ranges

Nominal Voltage	Base Case limits	Post Contingency[9] Limits
400 kV	370 kV to 410 kV	360 kV to 420 kV
220 kV	210 kV to 240 kV	200 kV to 245 kV
110 kV	105 kV to 120 kV	99 kV to 123 kV
275 kV	260 to 300 kV	250 to 303 kV

For **base case** operation, i.e. with all lines in service, the voltage step resulting from switching including capacitor and reactor switching shall not exceed 3.0%.

For single contingencies **(N-1)**, the maximum step change between pre- and post-**contingency steady-state** voltages shall not exceed 10%.

3.8.2 Phase angle on closing

The maximum permitted **phase angles** and minimum voltage amplitudes on re-closing, shall not exceed the limits in Table 3-4

Table 3-4 - Re-closing requirements

Nominal voltage (kV)	Phase angle (degrees)	Minimum voltage amplitude (%)
400	40	90
220	40	90
110	40	90

3.9 Thermal limits (normal and emergency)

The system shall normally be operated within the thermal limits of the **plant**. In emergencies, limits for **plant** and equipment are as outlined in Table 3-5. Temporary loading restrictions may be applicable from time to time as system conditions and the condition of the assets dictate. The normal and emergency ratings take account of the ratings of all auxiliary and ancillary equipment, such as switchgear, bushings, instrument transformers and tap changers.

Table 3-5 - Thermal Limits (Normal and Emergency)

Equipment	Emergency Rating	Minutes
Overhead Line	110% Normal Rating	30
Transformer	130% Normal Rating See EirGrid transformer overloading guide and	

[9] As defined in section 3.2

	criteria[10] (Appendix A)	
Cable	Emergency ratings shall be as calculated in accordance with IEC 60853 parts 2 and 3[11]	

3.10 Adjustment of system operation following a Disturbance[12]

Following a disturbance, the system shall be re-configured, including re-dispatch as required, to normal within two hours.

3.11 Outage management

Following the first **generator** or maintenance **outage** but before any potential trip outage, network re-configuration is permissible.

As a post–**contingency** remedial action, it is acceptable to plan on a reasonable amount of network switching to return the system to normal limits. This may result in load being tail fed that would not otherwise be tail fed.

Short term post fault action may be undertaken as stated in paragraph 3.1.

3.12 Risk management

The transmission system shall be operated in such a way that a **contingency**[13] does not lead to cascading **outages** violating security criteria. Regular **contingency** analysis shall be performed, and necessary preventative actions taken, on a regular basis and, in any case, before each switching action on any network element during real-time operation.

3.13 Short circuit levels

The transmission system shall be operated such that the actual short circuit levels do not exceed the rated short circuit levels of equipment on the system.

The system is operated such that line to earth voltage during single line to earth faults does not rise above 80% of the rated line to line voltage.

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[10] Transformer Temperature Indicator Modifications and Overloading Guide Update, 18 February 2004 (Appendix A)

[11] IEC 60853-2: 1989, Calculation of the cyclic and emergency current rating of cables – Part 2: Cyclic rating of cables greater than 18/30 (36) kV and emergency ratings for cables of all voltages and IEC 60853-3: 2002, Calculation of the cyclic and emergency current rating of cables – Part 3: Cyclic rating factor for cables of all voltages, with partial drying of the soil

[12] As defined in the Grid Code

[13] As defined in section 3.2

3.14 Voltage stability

Stable voltage control shall be maintained following the most severe credible **contingency** event (Table 3-6).The following criteria address post-transient or long-term voltage stability, the period after the transient oscillations have damped out, including the operation of automatic measures (re-dispatch, under voltage tripping and remedial action or special protection schemes), but before the TSO can take manual actions (typically up to 5 minutes). During this time some control equipment such as on-load tap changers would have time to adjust. The criteria comprise real and reactive power margins based on **P-V curves**.

Table 3-6 - Voltage stability criteria

Security criteria	MW Margin (P-V method)
N-1 contingency **N-G-1 contingency** **N-1-1 contingency**	≥ 5 % of the total load value at the point of collapse on the P-V curve

The criteria include the following provisions for application to local areas of the network:

- Controlled load shedding is allowed for the stated contingencies in order to meet the margins specified in the above table; and
- The margins in the table do not have to be met if the local area is radial and/or the **contingency** under consideration does not cause **voltage collapse** of the system beyond the local area.

3.15 Power system oscillations

The transmission system shall be operated such that it is transiently stable and shall meet the following criterion:

> The system shall have adequate damping and the target **damping ratio (ζ)** shall at least be 0.05.
>
> (Cigré Technical Brochure 111, page 2-5, states in respect of Ireland "For small disturbance stability, a relative damping coefficient of not less than 0.05 is desirable, giving a settling time of 16 sec. of a 0.8Hz oscillation.")

3.16 Power quality

Power quality measuring equipment shall be installed as necessary. The limits of distortion, fluctuation and voltage unbalance of the system voltage are as stated in:

- IEC/TR3 61000-3-6, Assessment of harmonic injection made by MV and HV installations and proposed limits, and;
- IEC/TR3 61000-3-7, Assessment of emission limits for fluctuating loads in MV and HV power systems, and;

- IEC 61000-3-13 Electromagnetic compatibility (EMC) - Part 3-13: Limits - Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems.

3.17 Fault clearance

Protection schemes are employed on the transmission networks to fulfil the following Functions:

- Minimise hazards associated with faults to staff, public and other utility workers.
- Minimise damage to faulted **plant** and prevent consequential damage to healthy **plant** during faults.
- Preserve system stability and security.
- Ensure continuity and quality of supply where possible.

The aim of Primary Protection is to clear faults at 400kV and 220kV within **100ms** and within **150 ms** at 110kV

The aim of Backup Protection is to clear faults within **0.5 s**

3.18 Facilities

The Energy Management System Platform shall consist of the National Control Centre (NCC), the Emergency Control Centre (ECC) and Dispatch Training Simulator (DTS).

In normal operation the power system is operated from the NCC, which is be manned by at least two fully qualified personnel at all times. However, to cater for the complete loss of NCC facilities, it shall be possible to carry out full system operation from the ECC location.

The following are defined as the critical functions of the SCADA/EMS system:

a) All standard SCADA functions of scanning Remote Terminal Units (RTUs), collection and processing of telemetered data, the execution of supervisory control, alarm and event processing including analogue limit checking, frequency acquisition and network topology processing.
b) Historical Information System (HIS)
c) Historical Data Recording (HDR) for disturbance data collection and processing.
d) At least 50% of all Operator Workstations operational.
e) EMS Software including state estimator, Powerflow and real-time plus study **Contingency** Analysis.
f) Inter-control centre communications.
g) Real-time User Interface (WebFG driven by SCADA/EMS hosts) and Replicated Data User Interface (WebFG driven by EMS Web hosts)
h) RTU and inter control centre telecommunications links

In addition the Electronic Dispatch Instruction Logging (EDIL) system and related data flows to/from the EMS are considered to be critical.

For each of the above critical functions, no single failure of equipment, software, cabling or power supplies shall cause loss of functionality.

The **Control Centre** should have remote control available for all 400kV, 220kV and all critical 110kV equipment under EirGrid's operational control.

3.19 Total Transfer Capacity (TTC) calculations

All TTC calculations will be carried out using the ETSO[14] procedures for cross-border transmission capacity assessments.

3.20 Training and certification

All grid controllers shall be duly authorised in order to work in the Control Centre and annual certification to this effect shall take place. Continuous training is required to maintain and extend the controllers' skills.

4 TERMS AND DEFINITIONS

4.1 Acronyms

A	Ampere
CER	Commission for Energy Regulation
CCGT	Combined Cycle Gas Turbine
Cigré	Conseil International des Grands Réseaux Electriques, www.cigre.org
DTS	Dispatcher Training Simulator
ECC	Emergency Control Centre
EHV	Extra High Voltage (> 300kV)
EMC	Electromagnetic Compatibility
EMS	Energy Management System

[14] European Transmission System Operators (www.etso-net.org) "Procedures for Cross-border Transmission Capacity Assessment", October 2001

EN	Euronorm (European Standard)
ETSO	European Transmission System Operators www.etso-net.org
ESB	Electricity Supply Board
Hz	Hertz
HV	High Voltage (36 to 300kV)
HVDC	High Voltage Direct Current
IEC	International Electrotechnical Commission www.iec.ch
IEC/TR	IEC Technical Report
kA	kilo Ampere
kV	kilo Volt
LV	Low voltage (< 1kV)
MV	Medium Voltage (1kV to 36kV)
MVA	Mega Volt-Ampere
MVAr	Mega Volt-Ampere reactive
MW	Megawatt
NCC	National Control Centre
OC	Operating Code (of the Grid Code)
SCADA	Supervisory Control and Data Acquisition
SONI	System Operator Northern Ireland
RTU	Remote Terminal Unit
TSO	Transmission System Operator
TTC	Total Transfer Capacity

4.2 Definitions

Base Case	As defined in the Transmission Planning Standards
CCGT unit	As defined in the Grid Code
Contingency	As defined in the Grid Code
Control Centre	As defined in the Grid Code
Corrective Action	Manual and automatic action taken after an outage or switching action to assist recovery of satisfactory switching conditions; for example, tap changing or switching of **plant**.
Damping Ratio (ζ)	As defined in Cigré Technical Brochure 111.
Demand	As defined in the Grid Code
Demand Control	As defined in the Grid Code
Demand Disconnection	As defined in the Grid Code
Demand Reduction	As defined in the Grid Code
External System	As defined in the Grid Code
External System Operator	As defined in the Grid Code
Generating Unit	As defined in the Grid Code
Generator	As defined in the Grid Code
Loss of power infeed	The output of a **generating unit** or a group of **generating units** or the import from the **External System** disconnected from the system by a **contingency**, less the **demand** disconnected from the system by the same **contingency**. The **loss of power infeed** includes the output of a single **generating unit**, or ***CCGT* unit**.
MW Output	As defined in the Grid Code
N-1 contingency	Loss of any single item of **generator** or transmission **plant** at any time
N-G-1	An overlapping single **contingency** and **generator** outage
N-1-1	An overlapping **contingency** in which the forced outage of a transmission or generating element occurs while another element is out on a scheduled local system outage (trip maintenance event)
Outage	As defined in the Grid Code
Phase angle	Angular difference between voltage vectors either side of an open circuit breaker.

Plant	As defined in the Grid Code
Power System Restoration Plan	As defined in the Grid Code.
P-V Curves	Power – Voltage curves for a receiving end node.
Remedial Action Scheme	**Special Protection Scheme**
Reserve	The additional increase in **MW Output** (and/or reduction in **Demand**) required with change of frequency.
Special Protection Scheme	As defined in the Grid Code
System	As defined in the Grid Code
System Instability	Poor damping or pole slipping.
	For the purposes of assessing the existence of system instability, a fault **outage** is taken to include a solid three phase to earth fault (or faults) any where on the transmission system with an appropriate clearance time.
Tail Fed	110 kV substation with a single connection at 110 kV
Tee	As defined in the Transmission Planning Standards
Tie-Line	Interconnection with the Other Transmission System, as defined in the Grid Code
Time error	The difference between standard time and the time based on the system frequency.
Transmission System	As defined in the Grid Code
Unacceptable Frequency Conditions	Frequency conditions outside those stated in Table 3-2.
Unacceptable Voltage Conditions	Voltages outside those stated in Table 3-3.
Unacceptable Overloading	The overloading of any transmission **plant** beyond the limits stated in Table 3-5.
Voltage collapse	Where progressive, fast or slow voltage decrease or increase develops such that it can lead to either tripping of **generator units** and/or loss of **demand**

APPENDIX A

TRANSFORMER OVERLOADING CRITERIA JANUARY 2004

The following criteria / experiences / assumptions have been used in establishing the transformer overloading guide—January 2004.

- An ambient temperature of 20^{0}C.
- Four categories for 220 / 275 / 400kV transformer are applied, based on design limitations and condition assessment tests, with four categories of loading. These are as follows:

	Rating % Nameplate (N)			
Type of Loading	**Category 1**	**Category 2**	**Category 3**	**Category 4**
Normal Cyclic Load *	130%	130%	110%	100%
Long Time Emergency Cyclic Loading *	130%	130%	110%	100%
Short Time Emergency Loading *	150%	130%	110%	100%

*As defined by IEC 354

- Field experience of nuisance temperature indicator alarms caused by solar radiation on transformers/ temperature indicator devices.

- Alarms and trips on temperature indicator devices for each category of 220 / 275 / 400kV transformer should be set as follows (maintain a 15^{0}C differential between the alarm and trip):

Category	Top Oil	Winding Hot Spot
1.	90/105^{0}C	120/135^{0}C
2.	90/105^{0}C	105/120^{0}C
3.	85/100^{0}C	85/100^{0}C
4.	80/95^{0}C	80/95^{0}C

- Where initial condition assessments have recommended further monitoring/ corrective maintenance to be carried out on transformers (see overloading guide comments section), this should be done as soon as possible. Condition assessments should be carried out on all transformers on a routine basis with an eight yearly cycle. The overloading guide should be updated annually on the basis of (i) new transformer installations, (ii) transformer retirements/ relocations, and (iii) life management data generated by transformer condition assessments/ monitoring.

  Transformers with fans and pumps should have temperature indicator control devices for these items set as follows:

- Fans should be set to operate at least 25°C below top oil alarm settings with 5°C differential between separate banks. *
- Pumps should be set to operate at least 20°C below top oil alarm settings with 5°C differential between separate banks. *

New transformers, purchase to IEC 354, to have temperature indicator alarm and trip settings as follows:

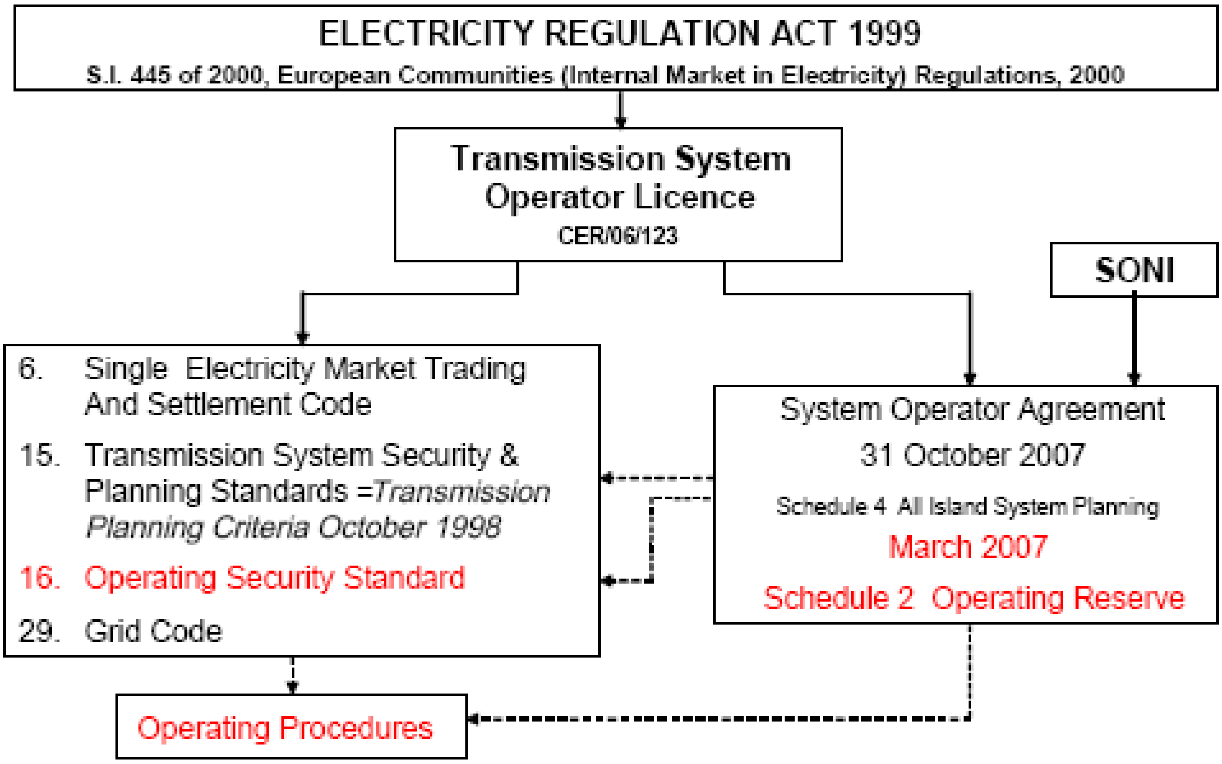
Top oil : 90 / 105°C
Winding hot spot : 120 / 135°C
*Set fans and pumps as **

APPENDIX B

STRUCTURE OF ELECTRICITY TRANSMISSION REGULATORY DOCUMENTS

In accordance with Condition 16, Operating Security Standard, of the Transmission System Operator (TSO) Licence, this document (Operating Security Standards) sets out the standards for ensuring day-to-day operating security of the transmission system. The structure of electricity transmission regulatory documents is presented in the diagram below.

STRUCTURE OF ELECTRICITY TRANSMISSION REGULATORY DOCUMENTS



Cigré defines security as a measure of power system ability to withstand sudden disturbances such as electric short circuits or unanticipated losses of system components or load conditions together with operating constraints. Another aspect of security is system integrity, which is the ability to maintain interconnected operations. Integrity relates to the preservation of interconnected system operation, or the avoidance of uncontrolled separation, in the presence of specified severe disturbances.