RfG

Reactive Power Capability / Excitation Limiters

[Insert Unit Name]

[Insert Three Letter Code]

Version 0.1



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# IPP TEST PROCEDURE VERSION History

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Document Revsion History** | | | | |
| **Revision** | **Date** | **Comment** | **Name** | **Company** |
| 0.1 | Xx/xx/xxxx | XX | User | User |
|  |  |  |  |  |
| 1.0 | Xx/xx/xxxx | Revised to Major version for onsite testing and signoff |  | EirGrid |

# Introduction

The Unit must submit the latest version of this test procedure as published on the EirGrid or SONI website[[1]](#footnote-1).

All yellow sections must be filled in before the test procedure will be approved. All grey sections must be filled in during testing. If any test requirements or steps are unclear, or if there is an issue with meeting any requirements or carrying out any steps, please contact [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com).

On the day of testing, suitably qualified technical personnel are required on site to assist in undertaking the tests. The personnel shall have the ability to:

1. Set up and disconnect the control system and instrumentation as required;
2. Ability to fully understand the Unit’s function and its relationship to the System;
3. Liaise with NCC/CHCC as required;
4. Mitigate issues arising during the test and report on system incidents.

The availability of personnel at NCC/CHCC will be necessary in order to initiate the necessary instructions for the test. NCC/CHCC will determine:

1. If network conditions allow the testing to proceed.
2. Which tests will be carried out?
3. When the tests will be carried out.

On completion of this test, the following shall be submitted to [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com):

|  |  |
| --- | --- |
| **Submission** | **Timeline** |
| A scanned copy of the test procedure, as completed and signed on site on the day of testing | 1 working day |
| Test data in CSV or Excel format | 1 working day |
| Test report | 10 working days |

# Abbreviations

NCC National Control Centre

CHCC Castlereagh House Control Centre

HV High Voltage

MEC Maximum Export Capacity

MVAr Mega Volt Ampere – reactive

MW Mega Watt

MCR Maximum Continuous Rating / Registered Capacity

TSO Transmission System Operator

EDIL Electronic Dispatch Instruction Logger

RPM Revolutions per minute

# unit DATA

|  |  |
| --- | --- |
| Unit Test Coordinator | Unit to Specify Name, Company and contact details. |
| Unit name | Unit to Specify |
| Associated 110 kV Station | Unit to Specify |
| Unit connection point | Unit to Specify |
| Unit connection voltage | Unit to Specify |
| Unit Fuel Type: | Primary Fuel / Secondary Fuel, Gas / Distillate. |
| Registered Capacity / Maximum Continuous Rating | Unit to Specify |
| Contracted MEC | Unit to Specify |
| Installed Plant | Unit to Specify |
| Minimum Load | Unit to Specify |

# eirgrid Grid Code References

|  |  |
| --- | --- |
| Grid Code Version: | Unit to specify |

CC.7.3.1.1 Each **Generation Unit,** shall, as a minimum, have the following capabilities:

g) sustained operation in accordance with the **Reactive Power** capability as required by CC.7.3.6 at **Transmission System Voltages** within the ranges specified in CC.8.3.2, unless otherwise specified;

1. Remain synchronised to the **Transmission System** and operate within the ranges of the **Transmission System** **Voltage** at the connection point, for an unlimited time period, as specified below:
2. 400 kV system: 360 kV to 420 kV (0.9 pu – 1.05 pu)
3. 220 kV system: 198 kV to 245 kV (0.9 pu – 1.114 pu)
4. 110 kV system: 99 kV to 123 kV (0.9 pu – 1.118 pu)

CC.7.3.6 **Reactive Power** capability

CC.7.3.6.1 Each **Generation Unit** shall have the following **Reactive Power** capability as measured at their alternator terminals:

|  |  |  |  |
| --- | --- | --- | --- |
| **Voltage** Range | Connected at: | At **Registered Capacity** between: | At 35% **of Registered Capacity** between: |
| |  | | --- | | 99kV ≤ **V** ≤ 123kV | | 110kV | 0.93 power factor leading to 0.85 power factor lagging | 0.7 power factor leading to  0.4 power factor lagging |
| 85kV ≤ **V** < 99kV | Unity power factor to  0.85 power factor lagging | 0.7 power factor leading to  0.4 power factor lagging |
| 200kV ≤ **V** ≤ 245kV | 220kV | 0.93 power factor leading to 0.85 power factor lagging | 0.7 power factor leading to  0.4 power factor lagging |
| 190kV ≤ **V** < 200kV | Unity power factor to  0.85 power factor lagging | 0.7 power factor leading to  0.4 power factor lagging |
| 360kV ≤ **V** ≤ 420kV | 400kV | 0.93 power factor leading to 0.85 power factor lagging | |  | | --- | | 0.7 power factor leading to 0.4 power factor lagging | |
| 350kV ≤ **V** < 360kV | Unity power factor to  0.85 power factor lagging | 0.7 power factor leading to  0.4 power factor lagging |

CC.7.3.6.2 At between **Registered Capacity** and 35% **Registered Capacity**, Mvar capability to be not less than indicated by a straight line drawn between the two points derived from the above, on a plot of Mvar capability against MW output.

CC.7.3.6.3 At below 35% **Registered Capacity**, Mvar capability to be not less than that at 35% **Registered Capacity**.

CC.7.3.6.4 The **Generator Transformer** shall be designed such that the **Reactive Power** capability is possible over the full range of **Transmission System** **Voltages** (specified in CC.7.3.6.1).

**CC.7.3.6.5**

|  |
| --- |
| **Generation Units** connecting to the **Transmission System** shall comply with the following **Reactive Power** requirements at **Maximum Capacity (Pmax)** at the **Connection Point**; |

The **Generation Unit** shall be capable of moving to any operating point with its U-Q/Pmax profile in appropriate timescale to target values. The appropriate timescale shall be identified during the **TSO’s Connection Offer** process.CC.7.3.6.6 The **TSO** and the **Generator** will liaise on matters related to CC.7.3.6 at the design stage.

**CC.7.3.6.7** For **Generation Units** where the **Connection Point** is remote from the **Grid Connected Transformer**, any supplementary **Reactive Power** compensation required to offset the **Reactive Power** demand of the HV line, or cable, between the **Connection Point** and the **Generation Unit** shall be identified during the TSO’s **Connection Offer** process.

CC.7.3.6.8 **Generation Units** shall be capable of providing **Reactive Power** at least down to **Minimum Generation.** Even at reduced **Active Power** output, **Reactive Power** supply at the **Connection Point** shall correspond fully to the **Reactive Power** capability of that **Generation Unit**, taking the auxiliary supply power and the **Active** and **Reactive Power** losses of the step-up transformer, if applicable, into account.

In the event of power oscillations, **Generation Units** shall retain steady-state stability when operating at any operating point of the **Reactive Power** capability

**Glossary:**

|  |  |
| --- | --- |
| **Automatic Voltage Regulation** | Automatic maintenance of a **Generation Unit's** terminal voltage or **Interconnector’s Reactive Power** output at a desired setpoint |
| **Energise** | The movement of any isolator, breaker or switch so as to enable active power and reactive power to be transferred to and from the Facility through the **Generator’s Plant** and **Apparatus** and “**Energised**” and “**Energising**” shall be construed accordingly. |
| **Generation Unit Output** | The **Active Power and Reactive Power** produced by a **Generation Unit** net of **Generation Unit Auxiliary Load** |
| **Load** | The **Active Power** or **Reactive Power**, as the context requires, generated, transmitted or distributed and all like terms shall be construed accordingly. |
| **Mvar Output** | The **Reactive Power** produced or absorbed by a **Generation Unit** net of **Generation Unit Auxiliary Load** |
| **Reactive Power** | Means the product of voltage and current and the sine of the phase angle between them measured in units of volt-amperes reactive and standard multiples thereof. |
| **Synchronous Compensation** | The operation of rotating synchronous **Apparatus** for the specific purpose of either the **Generation** or absorption of **Reactive Power**. |
| **Var** | A single unit of **Reactive Power**. |
| **Voltage Regulation** | The automatic adjustment of **Reactive Power** output from a **Generation Unit(s)** in response to **Voltage** changes (e.g. from a **Generation Unit**). |
| **Voltage Regulation Set-point** | The **Voltage** in kV that the **Voltage Regulation System** will act to regulate by continuous modulation of the **Interconnector’s Reactive Power**. |
| **Voltage Regulation System** | A facility providing the means to automatically adjust the **Reactive Power** output (e.g from a **Generation Unit**)**(s)** in response to changes in **Voltage**. |
| **Voltage Regulation System Slope Setting** | The percentage change in **Transmission System Voltage** that would cause the **Reactive Power** output of the **Interconnector** to vary from maximum **Mvar** production to maximum **Mvar** absorption or vice-versa. |

# SONI Grid Code references

|  |  |
| --- | --- |
| Grid Code Version: | Unit to specify |

CC.S1.1.3.2 For **CDGUs** and for **CCGT Installations** (in relation to the **CCGT Modules** therein) the **Reactive Power** capability shall as a minimum be:-

(i) rated power factor (lagging) = 0.8;

(ii) rated power factor (leading) = 0.95;

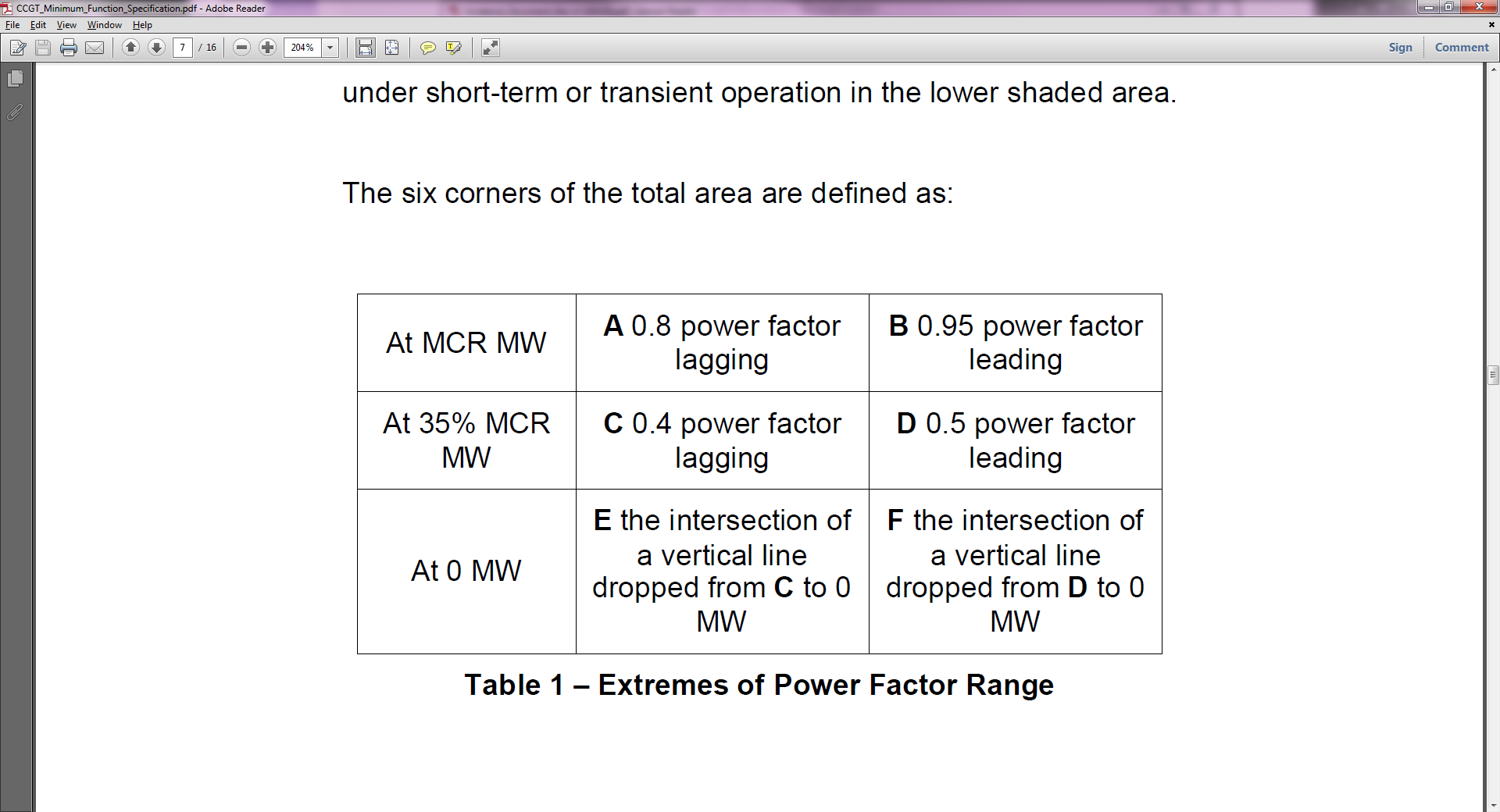
CC.S1.1.5.1 Each **Generating Unit** must be capable, in accordance with CC.S1.1.5.2 and CC.S1.1.5.3, of contributing appropriately, as reasonably specified by the **TSO**, to **Frequency** and voltage control by continuous modulation of **Active Power** and **Reactive Power** supplied to the **Transmission System**.

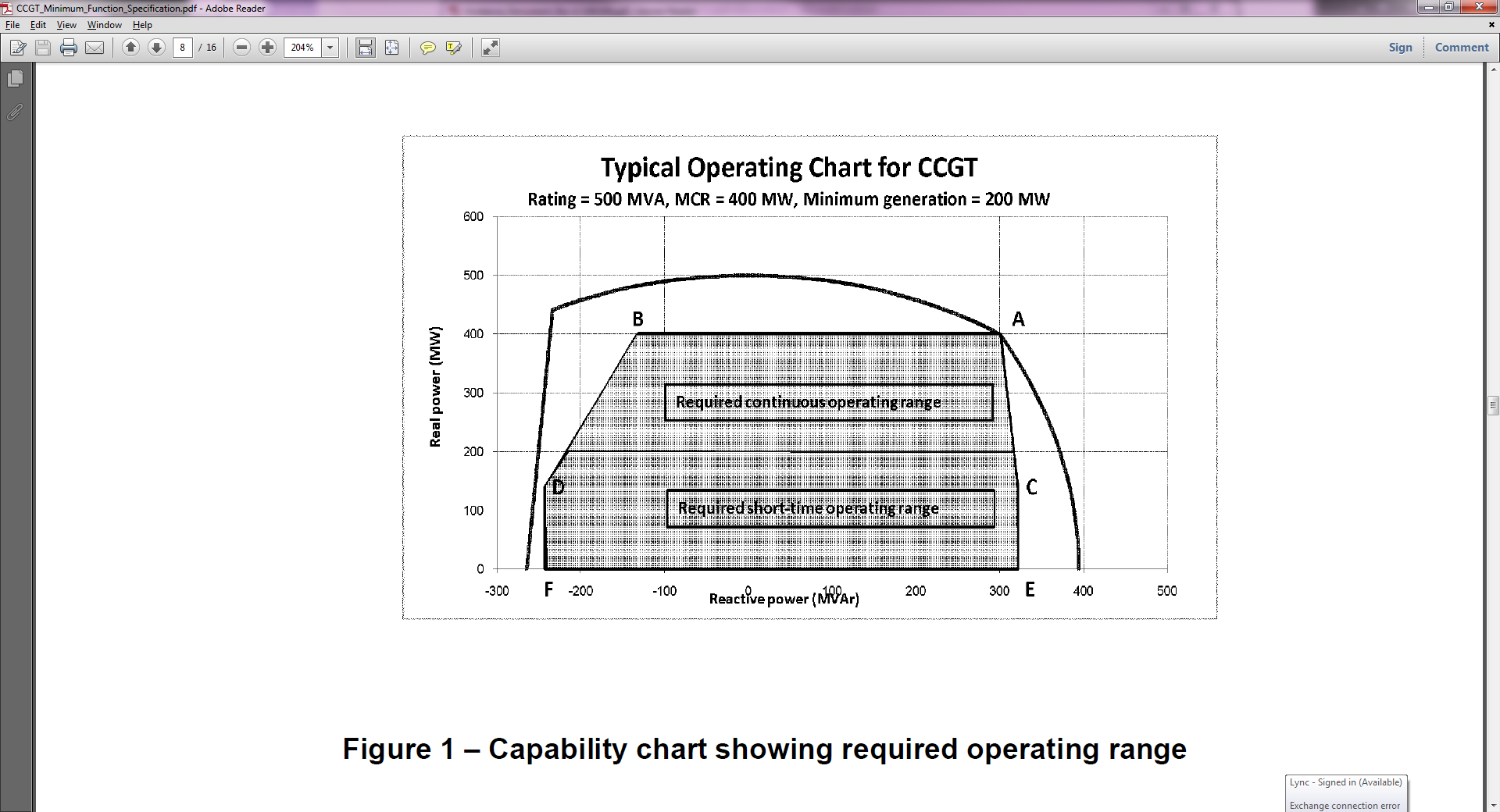
**Minimum Function Specification for centrally dispatched Closed Cycle Gas Turbines (CCGT)**

3.2 Reactive Power Capability

CCGT units must be capable of continuous operation within that shaded part of the generator capability chart (Figure 1) that lies above the Minimum Generation level at all temperatures within the site design temperature range. Units must be capable of providing reactive power under short-term or transient operation in the lower shaded area.

The six corners of the total area are defined as:



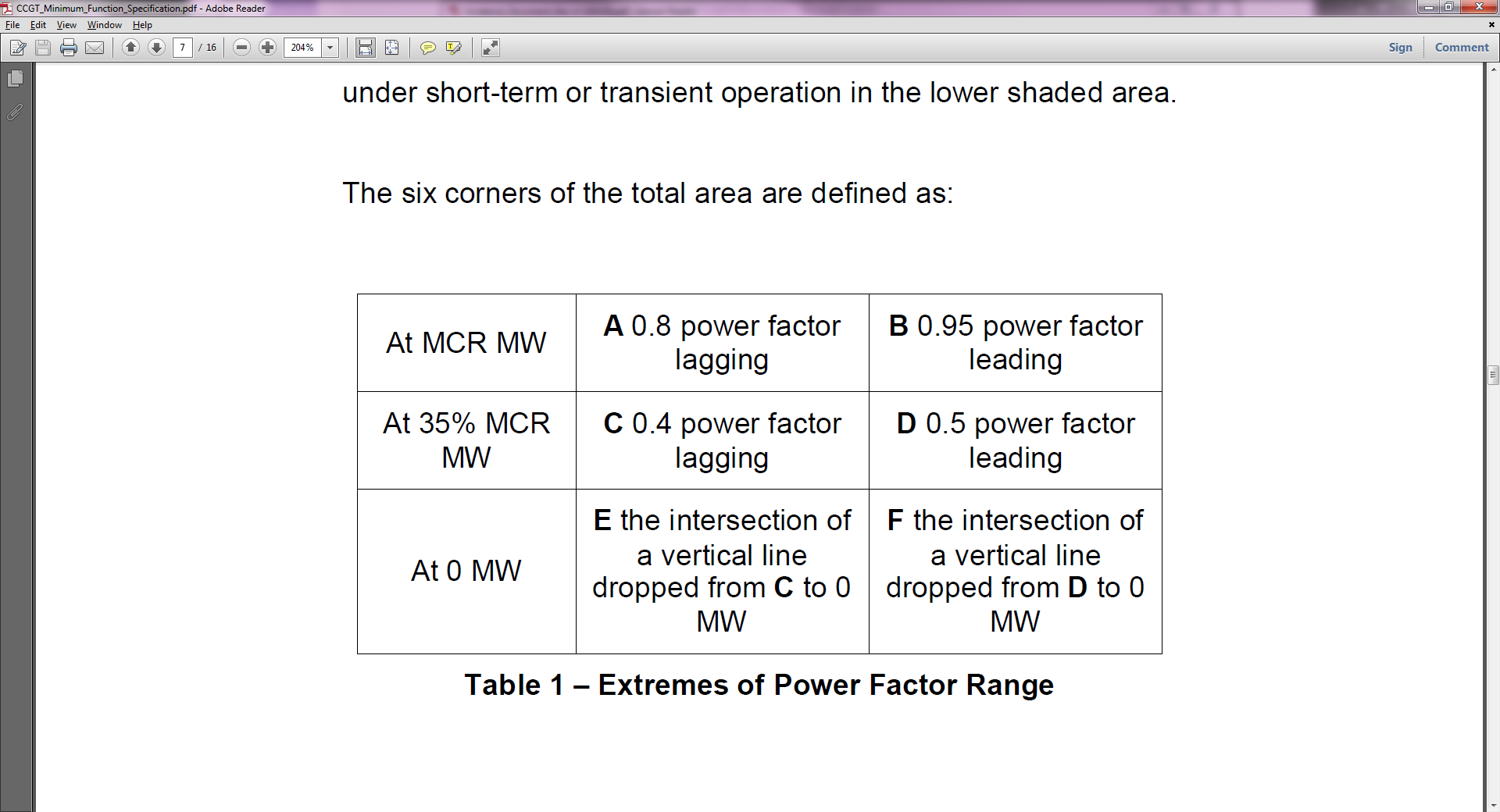


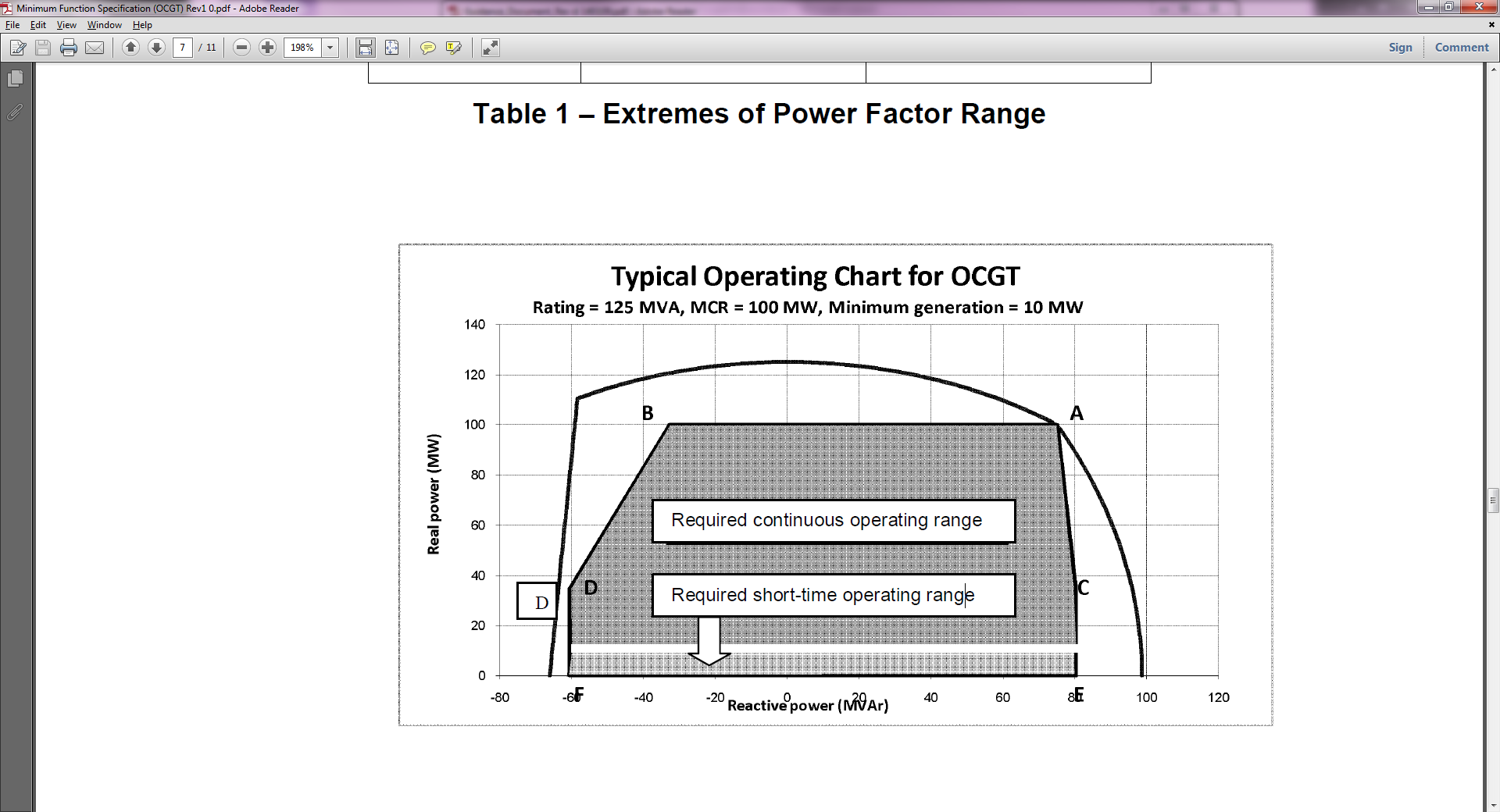
**Minimum Function Specification for centrally dispatched Open Cycle Gas Turbines (OCGT)**

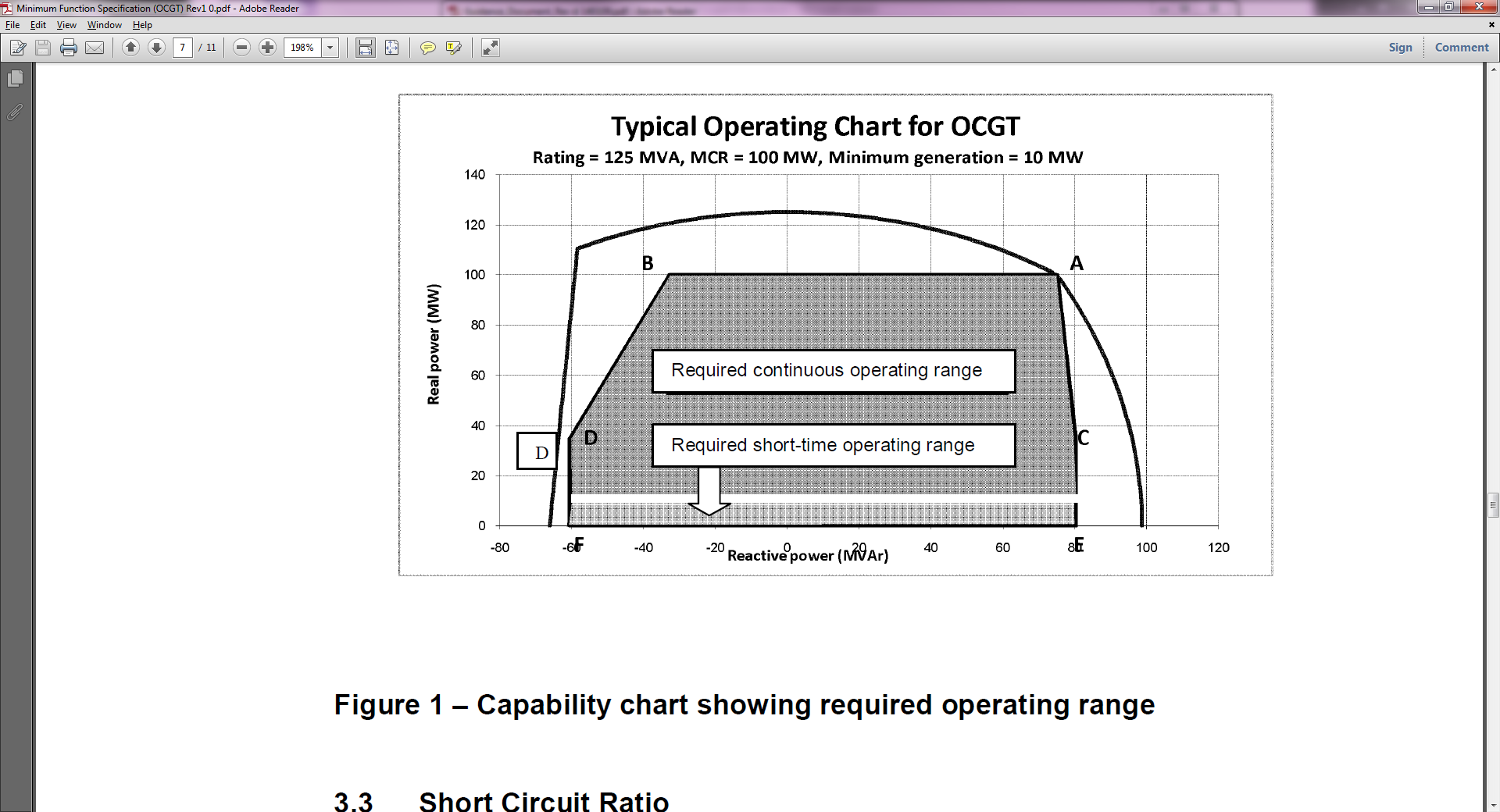
**3.2 Reactive Power Capability**

OCGT units must be capable of continuous operation within that shaded part of the generator capability chart (Figure 1) that lies above the Minimum Generation level at all temperatures within the site design temperature range. Units must be capable of providing reactive power under short-term or transient operation in the lower shaded area.

The six corners of the total area are defined as:







**Glossary:**

|  |  |
| --- | --- |
| **Automatic Voltage Regulator** or **AVR** | A continuously acting automatic excitation system to control the voltage of a **Generating Unit** as measured at the **Generator Terminals**. |
| **Generator Performance Chart** | A diagram which shows the **MW** and **Mvar** capability limits within which a **CDGU** or a **CCGT Module** within a **CCGT Installation** or a **Controllable WFPS** or **Dispatchable WFPS** willbe expected to operate under steady state  conditions in the formats set out in Appendix 1 to OC2, and which shows in addition, for a **Controllable WFPS** or **Dispatchable WFPS**, wind speed and direction against electrical output in **MW**, in “rose” format. |
| **Reactive Power** or **Mvar** | The product of voltage and current and the sine of  the phase angle between them measured in units of  volt-amperes reactive and standard multiples  thereof, i.e.:  1000 var = 1 kvar  1000 kvar = 1 Mvar |
| **Voltage Control** | The retention of the voltage on the **System** within acceptable limits. |

# site Safety requirements

The following is required for the EirGrid/SONI witness to attend site:

|  |  |
| --- | --- |
| Personal Protective Equipment Requirements   1. Site Safety boots 2. Hard Hat with chin strap 3. Hi Vis 4. Arc Resistive clothing 5. Safety Glasses 6. Gloves 7. Safe Pass | 1. Yes / No 2. Yes / No 3. Yes / No 4. Yes / No 5. Yes / No 6. Yes / No 7. Yes / No |
| Site Induction requirements | Yes / No  (If Yes, WFPS to specify how and when the induction must carried out) |
| Any further information | Unit to specify |

# Test description and pre conditions

## Purpose of the Test

The purpose of this test is to demonstrate the stable operation of the Unit at the MW/MVar levels as per Grid Code requirements.

This test shall also demonstrate the stable operation of the unit while under the control of automatic excitation limiters.

## Pass Criteria

The following is the pass criteria for the test. Any subsequent report for this test will be assessed against each of these criteria.

1. The Unit power output shall be within the required band.
2. The Unit is capable of stable operation while under the control of the under-excitation limiter.
3. The Unit is capable of stable operation while under the control of the over-excitation limiter.

## Instrumentation and onsite data trending

All of the following trends must be recorded by the Unit during the test. Failure to provide any of these trends will result in test cancellation.

|  |  |  |  |
| --- | --- | --- | --- |
| **No.** | **Data Trending and Recording** | **Resolution** | **Check On Day Of Test** |
| 1 | Active power at Connection (MW) | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 2 | Reactive power at Connection point (MW) | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 3 | Active Power at Generator Terminals (MW) | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 4 | Reactive Power at Generator Terminals (Mvar) | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 5 | Generator Voltage (kV) | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 6 | Turbine Speed (RPM) | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 7 | Generator Transformer Tap setting | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 8 | System Voltage | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 9 | System Frequency | Unit to specify, 100ms or as agreed with TSO | Unit to specify |
| 12 | Other signals as required by the unit or by [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com). | Unit to specify | Unit to specify |
| 13 | Alarm/Event page | Screenshot alarms/events for duration of the test. | |
| 14 | Generator Overview Screen | Screenshot at appropriate milestones during the test i.e. Before, during at regular intervals and after test from generator overview page on DCS | |
| 15 | EDIL instructions | Screenshot as logged during the test. | |

## Initial Conditions

Should “No” be answered to any of the following, contact the EirGrid/SONI Test Coordinator and agree next steps in advance of making any corrective actions.

|  |  |  |
| --- | --- | --- |
| **No.** | **Conditions** | **Check on day of test** |
| 1 | Test Profiles have been submitted and approved by [neartime@eirgrid.com](mailto:neartime@eirgrid.com). | Yes/No |
| 2 | Unit Fuel Type: Primary Fuel / Secondary Fuel, Gas / Distillate. | Yes/No |
| 3 | Correction curves (Temperature, humidity, atmospheric pressure) have been provided to [generator\_testing@eirgrid.com](mailto:generator_testing@eirgrid.com). | Yes/No |
| 4 | Frequency Response mode On / Off. | Yes/No |
| 5 | Unit is on load and stable in agreement with NCC/CHCC. | Yes/No |
| 6 | Normal start up support auxiliary systems are aligned and in service. | Yes/No |
| 7 | Required signals, as described in section 8.3 are available. | Yes/No |

# Test Steps

|  |  |  |  |
| --- | --- | --- | --- |
| **Step No.** | **Action** | **Time** | **Comments** |
| 1 | Unit operator begins data recording for all trends noted in Section 8.3. |  |  |
|  | **OVER EXCITED TESTS** |  |  |
| 2 | Unit operator contacts NCC/CHCC and requests permission to begin test and a dispatch instruction to **Registered Capacity** via EDIL. |  | Registered Capacity: \_\_\_\_ MW |
| 3 | Unit operator receives EDIL instruction, dispatches the Unit to **Registered Capacity** and allows the Unit to stabilise for 10 mins. |  |  |
| 4 | With the Unit at Registered Capacity the operator adjusts the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allows the Unit to thermally stabilise. |  |  |
| 5 | With the Unit at Registered Capacity and the generator thermally stabilised run for an additional 30 minutes and record all data. |  |  |
| 6(a) | Ireland: Adjust the generator terminal voltage to 105% rated. |  | 105% rated voltage: \_\_\_\_\_ kv |
| 6(b) | Northern Ireland: Adjust the generator terminal voltage to 110% rated (Transmission connected generation) or 106% rated (Distribution connected generation) |  | 110% rated voltage: \_\_\_\_\_ kv  Or  106% rated voltage: \_\_\_\_\_ kv |
| 7 | With theUnit at Registered Capacity and the Generator terminal voltage at XX% rated adjust the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allow it to thermally stabilise. |  |  |
| 8 | With theUnit at Registered Capacity and the Generator terminal voltage at XX% rated and the generator thermally stabilised run for an additional 30 minutes and record all data. |  |  |
| 9 | With theUnit at Registered Capacity adjust the PF to unity. |  |  |
| 10(a) | Ireland: Adjust the generator terminal voltage to 95% rated |  | 95% rated voltage: \_\_\_\_\_ kv |
| 10(b) | Northern Ireland: Adjust the generator terminal voltage to 90% rated (Transmission connected generation) or 94% rated (Distribution connected generation). |  | 90% rated voltage: \_\_\_\_\_ kv  Or  94% rated voltage: \_\_\_\_\_ kv |
| 11 | With theUnit at Registered Capacity and the Generator terminal voltage at XX% rated adjust the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allow it to thermally stabilise. |  |  |
| 12 | With theUnit at Registered Capacity and the Generator terminal voltage at XX% rated and the generator thermally stabilised run for an additional 30 minutes and record all data. |  |  |
| 13 | With theUnit at Registered Capacity adjust the PF to unity. |  |  |
| 14 | Command a 5% increase to the AVR and hold for 10 seconds. Confirm that the OEL alarm comes in. Allow unit to stabilise for 5 mins. |  |  |
| 15 | Adjust theAVR OE settings and then adjust GSU tap changer to confirm OEL activates and adjusts AVR response |  |  |
| 16 | Return the AVRsettings to normal and allow unit to stabilise for 10 minutes |  |  |
| 17 | With theUnit at Registered Capacity adjust the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve in preparation for the AVR Ceiling Test |  |  |
| 18 | Command a 10% increase to the AVR and hold for 0.1 seconds. |  |  |
| 19 | Return the AVRsettings to normal and allow unit to stabilise for 10 minutes |  |  |
| 20 | Unit operator contacts NCC/CHCC and requests permission to begin test and a dispatch instruction to 75% **Registered Capacity** via EDIL. |  | 75% Registered Capacity: \_\_\_\_MW |
| 21 | Unit operator receives EDIL instruction, dispatches the Unit to 75% **Registered Capacity** and allows to stabilise for 10 mins. |  |  |
| 22 | With the Unit at 75% Registered Capacity the operator adjusts the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allows the Unit to thermally stabilise. |  |  |
| 23 | With the Unit at 75% Registered Capacity and thermally stabilised run for an additional 30 mins and record all data. |  |  |
| 24(a) | Ireland: Unit operator contacts NCC and requests permission to begin test and a dispatch instruction to 50% **Registered Capacity** via EDIL. |  | 50% Registered Capacity: \_\_\_\_MW |
| 24(b) | Northern Ireland: Unit operator contacts CHCC and requests permission to begin test and a dispatch instruction to 35% **Registered Capacity** via EDIL. |  | 35% Registered Capacity: \_\_\_\_MW |
| 25 | Unit operator receives EDIL instruction, dispatches the Unit to 50/35% **Registered Capacity** and allows the Unit to stabilise for 10 mins. |  |  |
| 26 | With the Unit at 50/35% Registered Capacity the operator adjusts the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allows the Unit to thermally stabilise. |  |  |
| 27 | With theUnit at 50/35% of Registered Capacity and thermally stabilised run for an additional 30 minutes and record all data |  |  |
|  | **UNDER EXCITED TESTS** |  |  |
| 28 | Unit operator contacts NCC/CHCC and requests permission to begin test and a dispatch instruction to **Registered Capacity** via EDIL. |  | Registered Capacity: \_\_\_\_ MW |
| 29 | Unit operator receives EDIL instruction, dispatches the Unit to **Registered Capacity** and allows the Unit to stabilise for 10 mins. |  |  |
| 30 | With theUnit at Registered Capacity adjust the Mvars to the rated value for leading Mvars on the Generator Capability Curve and allow it to thermally stabilise. |  |  |
| 31 | With theUnit at Registered Capacity and the generator thermally stablised run for an additional 30 minutes and record all data. |  |  |
| 32 | With theUnit at Registered Capacity adjust the Mvars to the less than the rated value for leading Mvars on the Generator Capability Curve and allow it to thermally stabilise. |  |  |
| 33 | Adjust the UEL settings to just below operating levels |  |  |
| 34 | Command a 2% reduction to the AVR and hold for 10 seconds. Confirm that the UEL alarm comes in and allow the Unit to stabilise for 5 mins. |  |  |
| 35 | With theUnit at Registered Capacity adjust the Mvars to the rated value for leading Mvars on the Generator Capability Curve and allow it to stabilise for 5 minutes. |  |  |
| 36 | Restore the unit to pre-test MW and Mvar levels. Allow unit to stabilise for 5 mins |  |  |
| 37 | Unit operator contacts NCC/CHCC and requests permission to begin test and a dispatch instruction to 75% **Registered Capacity** via EDIL. |  | 75% Registered Capacity: \_\_\_\_MW |
| 38 | Unit operator receives EDIL instruction, dispatches the Unit to 75% **Registered Capacity** and allows to stabilise for 10 mins. |  |  |
| 39 | With the Unit at 75% Registered Capacity the operator adjusts the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allows the Unit to thermally stabilise. |  |  |
| 40 | With the Unit at 75% Registered Capacity and thermally stabilised run for an additional 30 mins and record all data. |  |  |
| 41 | Unit operator contacts NCC/CHCC and requests permission to begin test and a dispatch instruction to 50% **Registered Capacity** via EDIL. |  | 50% Registered Capacity: \_\_\_\_MW |
| 42 | Unit operator receives EDIL instruction, dispatches the Unit to 50% **Registered Capacity** and allows the Unit to stabilise for 10 mins. |  |  |
| 43 | With the Unit at 50% Registered Capacity the operator adjusts the Mvars to the rated value for Lagging Mvars on the Generator Capability Curve and allows the Unit to thermally stabilise. |  |  |
| 44 | With theUnit at 50% of Registered Capacity and thermally stabilised run for an additional 30 minutes and record all data |  |  |
| 45 | Unit operator contacts NCC/CHCC and notifies them that the test is complete. |  |  |
| 46 | Unit operator follows NCC/CHCC instruction. |  | Instruction from NCC/CHCC \_\_\_\_\_\_ |
| 47 | Unit operator ends data recording for all trends noted in Section 8.3 |  |  |

|  |
| --- |
| **Comments:** |
| Unit Witness signoff that this test has been carried out according to the test procedure, above.  Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date / Time: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |
| EirGrid/SONI Witness signoff that this test has been carried out according to the test procedure, above.  Signature: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Date / Time: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ |

1. <http://www.eirgrid.com/operations/gridcode/compliancetesting/cdgutestprocedures/#d.en.17699> [↑](#footnote-ref-1)