INSTALLATIONS CONNECTED TO A POWER TRANSMISSION SYSTEM AND GENERATING EQUIPMENT: MINIMUM DESIGN REQUIREMENTS, EQUIPMENT, OPERATIONS, COMMISSIONING AND SAFETY.

P.O. 12.2

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This is an unofficial translation of the latest draft of the Spanish grid code.

Source: Jason MacDowell, GE Energy
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1. OBJECT

The object of this procedure is to establish the minimum requirements governing design, equipment, operation, commissioning and safety of installations connected to the power transmission system and of production installations included in the scope of application.

2. SCOPE OF APPLICATION

This procedure is applicable to the following elements of the Spanish peninsular power system.

- The system operator and the transmission grid manager.
- The single transmission company.
- Distributors and consumers connected to the transmission system.
- Owners of production installations connected to the transmission system.
- Owners of production installations connected to the distribution system and that significantly affect the transmission system. In this case, the generating companies or groups of generating companies with a registered nominal power above 10 MW per node linked to the transmission system will be considered, if the said effects are caused by generation contingencies above 1 MW that share a connection node on the distribution grid.

3. GENERAL CONSIDERATIONS

The transmission company that owns the grid to which an installation is to be connected will supervise, at least, the design and project of the said installation concerning the aspects indicated in this procedure; the rest of the project will be conceived and executed in line with the criteria of the owner of the installation, who will be responsible for complying with applicable regulations and legislation at all times and of starting-up the installation, which will require the relevant authorization from the transmission company, the system operator and the manager of the transmission grid.

In any case, it will be the responsibility of the connected agent to provide prior justification and to comply with all the requirements established in this procedure, which will require drawing up methods of accreditation or certification and verification of the services required.

3.1 Energy Exchange Conditions

Article 23 of R.D. 1955/2000 establishes that the transfer of energy at boundary points between the transmission system and agents connected to the system must comply with the conditions of frequency and permanent voltage and those defined for reactive power established in the Additional Technical Specifications of the said R.D. and in the system’s operational procedures.
Furthermore, article 24 of R.D. 1955/2000 establishes that the system operator and transmission grid manager will be responsible for providing the owners of the electricity installations with instructions concerning the operation of the system and for managing complementary services to guarantee the safety of the system and compliance with the quality levels defined in the relevant additional technical specifications at all boundary points and with all agents connected to the transmission grid.

With this in view, current legislation on transmission system service quality and operational procedure 1.4 “Conditions of power delivery at boundary points of the grid managed by the system operator” will be applicable.

The installations must be capable of supporting, without damage or becoming disconnected, the values indicated in the above-mentioned operational procedure concerning nominal values of frequency, voltage swing and occurrence of events, as well as concerning the nominal value and variations in the root mean square voltage. Additionally, section 8 of this procedure will be applicable to generating companies.

The installation will not produce and, in turn, will be able to support without damage or becoming disconnected, surges of up to 4% in permanent voltage during any event. These values are understood to be within the limits established in P.O. 1.4.

On the other hand, all generation units must be capable of supporting a reverse current that is 5% of the nominal current.

3.1.1. Supply continuity

The installation must be capable of supporting, without damage, the values indicated in current regulations on transmission system service quality.

The quality ratios for transmission installations will be those established in R.D. 1955/2000 or in the document that replaces it.

3.1.2. Product quality

Product quality refers to the set of features of the voltage wave. The most significant features that may affect product quality are:

- **Voltage dips:** A voltage dip is a brusque drop in the power voltage to a value situation between 90% and 1% of the grid’s nominal voltage, followed by the recovery of the voltage after a short time. Conventionally, a voltage dip is understood to last between 10 ms and 1 minute. The depth is defined as the difference between the minimum rms voltage during the dip and the nominal voltage. Concerning voltage dips, all installations should be capable of supporting the values defined in the current regulations without suffering any damage.

- **Flicker:** Voltage fluctuations cause variations in the intensity of lights, which produces a phenomenon known as flicker. Therefore, flickering is an effect of a subjective nature...
linked to the impression of instability in the visual perception caused by light whose brightness varies in time.

- **Harmonics**: Harmonic voltage is defined as sinusoidal voltage whose frequency is a full multiple of the fundamental frequency of the supply voltage.

- **Voltage imbalance**: Voltage imbalance is a state in which the rms voltage values of phases or phase displacement between the voltages of consecutive phases, in a three-phase system, are not equal.

This section establishes the planning levels and emission limits of the most significant features of the voltage wave at boundary points between the transmission system and the agents connected to it:

a. **Planning levels**: these are used to define the maximum levels of electromagnetic distortions for which a given grid has been designed. Planning levels can be considered quality targets and can be used to assess the impact of the said distortions on consumers:

- **Flicker**: According to CEI 61000-3-7: “Assessment of emission limits for the connection of fluctuating installations to MV, HV and EHV power systems”, the following planning levels have been established for a transmission system:
  \[
  P_{st} \leq 1.0 \\
  P_{lt} \leq 0.8
  \]

  With these limits, the HV to LV transfer coefficient has been taken into account and, therefore, they should be compared with the flicker calculated for HV.

- **Harmonics**: According to CEI 610003-6: “Assessment of emission limits for the connection of distorting installations in MV, HV and EHV power system” and with a view to guaranteeing appropriate quality, the following harmonic voltage planning levels will be used on the transmission system:
### Table

<table>
<thead>
<tr>
<th>Harmonic Order (n)</th>
<th>Harmonic Ratio (%)</th>
<th>Harmonic Order (n)</th>
<th>Harmonic Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>2.0</td>
<td>2</td>
<td>1.5</td>
</tr>
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<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>2.0</td>
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</tr>
<tr>
<td>13</td>
<td>1.5</td>
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</tr>
<tr>
<td>15</td>
<td>0.3</td>
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<td>1.0</td>
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</tr>
<tr>
<td>21</td>
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<td>20</td>
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</tr>
<tr>
<td>23</td>
<td>0.7</td>
<td>22</td>
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</tr>
<tr>
<td>25</td>
<td>0.70</td>
<td>&gt;22</td>
<td>0.20</td>
</tr>
<tr>
<td>&gt;25</td>
<td>0.2 + 0.5*25/n</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Harmonic Distortion (THD) 3.00%**

- **Voltage imbalance**: The planning levels established for the level of imbalance (µ), expressed in % between the reverse sequence voltage component (vector quantity) and the direct sequence voltage component (vector quantity) are based on the duration of the said imbalance and are indicated below:

  \[ \mu \leq 1\% \text{ for imbalances that exceed 10 minutes (short duration limit)} \]

  \[ \mu \leq 2\% \text{ for imbalances that fluctuate in periods of up to 10 minutes (very short duration limit)} \]

- **Distortion emission limits**: Defined as electromagnetic distortions emitted by all the specific devices, components or systems connected to the same node and measures in accordance with certain specifications:

  - **Flicker**: The following flicker emission limits have been established for each node in the transmission system:
    
    \[
    \begin{align*}
    \text{Pst} & \leq 0.8 \\
    \text{Plt} & \leq 0.6
    \end{align*}
    \]
    
    With these limits, the HV to LV transfer coefficient has been taken into account and, therefore, they should be compared with the flicker calculated or measures for HV.

  - **Harmonics**: With a view to not exceeding the planning levels indicated above, the following harmonic voltage emission limits have been established for each node of the transmission system:
<table>
<thead>
<tr>
<th>Harmonic Order (n)</th>
<th>Harmonic Ratio (%)</th>
<th>Harmonic Order (n)</th>
<th>Harmonic Ratio (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.80</td>
<td>2</td>
<td>1.00</td>
</tr>
<tr>
<td>5</td>
<td>1.80</td>
<td>4</td>
<td>0.90</td>
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<tr>
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<td>11</td>
<td>1.30</td>
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</tr>
<tr>
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<td>1.30</td>
<td>12</td>
<td>0.20</td>
</tr>
<tr>
<td>15</td>
<td>0.30</td>
<td>14</td>
<td>0.20</td>
</tr>
<tr>
<td>17</td>
<td>0.90</td>
<td>16</td>
<td>0.20</td>
</tr>
<tr>
<td>19</td>
<td>0.90</td>
<td>18</td>
<td>0.20</td>
</tr>
<tr>
<td>21</td>
<td>0.20</td>
<td>20</td>
<td>0.20</td>
</tr>
<tr>
<td>23</td>
<td>0.60</td>
<td>22</td>
<td>0.20</td>
</tr>
<tr>
<td>25</td>
<td>0.60</td>
<td>&gt;22</td>
<td>0.20</td>
</tr>
<tr>
<td>&gt;25</td>
<td>0.20</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Harmonic Distortion (THD) 3.00%

- **Voltage imbalance**: The emitting elements of this type of distortion should not exceed the following total voltage distortion values at each node of the transmission system:
  
  \[
  \mu \leq 0.7\% \text{ for values in minutes (short duration limit)}
  \]
  
  \[
  \mu \leq 1\% \text{ for values in seconds (very short duration limit)}
  \]

In the event of connecting installations that are potentially distorting, the assessment of the feasibility of the access will be based on prior calculations in accordance with the requirements indicated; which may lead to the limitation of the access capacity or to the installation of compensating equipment by the applicant. Additionally, acceptance of access is subject to the condition that if any unacceptable emission values concerning any type of distortion (harmonics, imbalance, flicker, voltage dips…) appear once the installation is operational, the owner will have to take the necessary measures to reduce the said emissions to acceptable levels.

In order to compare the measurements with the limits, the document “Conditions for measuring distortions on the transmission system”, included in Appendix I, will be used.

3.1.3. Power exchanged

Power exchanged between the transmission system and non-transmission installations must not exceed that defined by the system operator in the Access Feasibility Report and indicated
by the transmission company in the Connection to the Transmission System Report. Consequently, if necessary, it will be limited by means of physical devices and/or operational procedures so as not to exceed the values established in the contract.

This requirement and, if relevant, the method required to implement it, must be approved by the system operator and the manager of the transmission system. In cases where the use of these devices, when they exist, may potentially interfere with the safety of the system, the system operator and the manager of the transmission system may request the scheduled disconnection of the installation.

3.2. Short circuit power and insulation co-ordination

3.2.1 Short circuit power

The non-transmission installations of the grid connection (see section 4. Connection to the transmission system) will be designed, in general, to support short term short circuit power of 50 kA at 400 kV and 40 kA at 220 kV at least. In the particular case of a connection to transmission systems using shielding technology, the minimum value would be 50 kA, also at 220 kV.

These values have been established based on the reference values indicated in P.O. 13.1 on criteria governing the development of transmission systems and in P.O. 13.3 on transmission installations.

In any case, the system operator and transmission system manager may require design values higher than those indicated, if the safety of the system and its correct operation justify such a requirement.

In the case of connections to the transmission system where the voltage is different from 220 and 400 kV, the system operator and the transmission system manager will confirm the design value required for non-transmission grid connection installations on a case by case basis.

Additionally, installations connected to the transmission system that do not belong to the grid connection installation will be designed to support, without damage, the short circuit power that the transmission system can provide.

With a view to guaranteeing the effectiveness of the switchgear of the transmission substation and the integrity of the rest of the equipment, designed for a given short circuit power, the contribution to the short circuit power of the installation connected plus that contributed by the system simultaneously at a given point will not imply a short circuit intensity, whether shorted or supported, higher than 85% of the level acceptable for the weakest element of the existing or planned transmission substation.

If the owner of the installation connected to the transmission system wishes to increase the said limit, the changes to the transmission system will be paid by that party.
All installations connected to the transmission network must feature a physical device and/or operational procedures that limit the short circuit power with a view to guaranteeing compliance with the above-mentioned limits.

If it should prove impossible to keep the short circuit power below acceptable levels (using operational methods), production restrictions may be applied.

The system operator and the transmission system manager will provide the expected short circuit power values and margins at the connection point in accordance with the contents of operational procedure 1.4 “Conditions for power provision at boundary points on the grid managed by the system operator”.

Minimum short circuit power values cannot be guaranteed, although the system operator and manager of the transmission system will provide a statistical estimate based on values obtained over previous years.

3.2.2. Insulation co-ordination

The criteria included in UNE EN 60071 will be applied.

3.3 Automatisms

Operational procedures 11.2 “Criteria governing the installation and operation of automatisms” and 1.6 “Implementation of safety plans for the operation of the system” establish the existence of certain automatic and remote tripping devices. The installation should feature the appropriate elements for the reception and execution of applicable remote instructions from dispatch.

3.3.1. Remote tripping

The appropriate physical devices or procedures will be installed to guarantee compliance with all limits on exchanged power established by the system operator and the transmission system manager.

3.3.2. Control systems and equipment

3.3.2.1. Control of generation-demand imbalance

Section 8 of the present operational procedure establishes the technical requirements covering this aspect for production installations, and operational procedure 7.1 “Primary regulation complementary service”, which is applicable to all production companies, establishes the requirements on primary regulation complementary services that generation installations must observe.

3.3.2.2. Voltage control
Voltage control mechanisms on the transmission system are included in operational procedures 8.3 “Voltage control on the grid” and 7.4 “Transmission system voltage control complementary service”. Additionally, the present operational procedure, in section 8, establishes the technical requirements for production installations on this issue. The object is to guarantee that voltage levels at grid nodes are correct to comply with established safety and quality levels.

4. CONNECTION TO THE TRANSMISSION SYSTEM

The agent accessing the transmission system will subscribe a Technical Access Contract with the transmission company that owns the connection point, which will consider the existence of access interruptions required to execute work scheduled on the grid or unforeseen circumstances. With this in view, the Technical Access Contract will reflect, through estimated transmission installations maintenance and renewal windows, the best prediction of the maintenance plan of the transmission installations that will affect the connection installation.

In relation to this procedure, grid connection installations are understood to be elements that, regardless of the activity regime they form part of, make the connection between non-transmission and transmission installations possible and should be considered as a whole and co-ordinated in relation to design, assembly, tests and commissioning.

The limits affecting a link installation, the boundary between the transmission system and non-transmission elements, and a connection installation as defined in R.D. 1955/2000, are represented in the graphs in section 5.

As can be appreciated in the said diagrams, a link installation comprises transmission and non-transmission elements, with a single voltage when the connection takes place via a line and two voltages when connection is via a transformer. A connection installation (RD 1955/2000), on the other hand, only comprises non-transmission installations at transmission voltages.

According to R.D. 1955/2000, the elements that integrate the transmission system will feature appropriate transmission devices to tend to the needs of the technical management of the electric system, as well as to guarantee the safety of the said system against external distortions.

If the connection is made via a non-transmission line, the protection, control and communications equipment linked to the said line installed in the transmission substation will guarantee the correct co-ordination and standardization of the equipment and systems in the transmission substation.

If the connection is performed via a non-transmission transformer, the protection equipment of the device will be located in the non-transmission installation and will be of a non-transmission nature; however, the protection equipment linked to the transmission switchgear will have a transmission nature. This makes it possible for each installation to have its own co-ordination and standardization criteria.
The official measurement will be performed as defined in the unified Regulation on electric system measuring points, R.D. 1110/2007 of 24th August or later, in force. For details on the installation of equipment see section 6.1 on shared installations.

Changes to the transmission system to enable the connection of non-transmission installations will comply with the criteria on transmission system development established in P.O. 13.1.

Requirements governing transmission installations, both concerning changes to existing substations or new installations are included in P.O. 13.3 “Transmission system installations: design criteria, minimum requirements and verification of equipment and commissioning”.

Application of boundary criteria to different connection installations.

i. **Generation**

1. Special regime generation: in the case of power generation under the special regime that has been assigned the same connection point (substation) to the transmission system, the said connection will be performed as a preferential solution to a single position.

2. Standard regime generation: the number of connection points will be defined in an agreement with the transmission company.

The joint installation will be defined as follows:
| **Transmission installation** | • Substation busbars connection points to the transmission system and all their points (connection of transmission and non-transmission elements to the substation).
• Connection by means of overhead line: complete position to the connection point of the line at the first substation point.
• Connection by means of a cable: complete position, to the connection cable terminal at the substation (the terminal is non-transmission).
• Connection by means of transformer: complete position to the voltage transformer, excluding the said transformer, the surge diverters and connection elements between these and the transformer.
• Management (maintenance and operation) of the above. |
| **Non-transmission installation** | **Connection by line:**
• Generation side substation.
• Connection line or lines between non-transmission and transmission areas.
• Management (maintenance and operation) of the above.

| **Connection by means of transmission / non-transmission power transformer.** |
| • Generation side substation.
• The power transformer or transformers, transmission / non-transmission (including surge diverters and connection elements with the transformer).
• Management (maintenance and operation) of the above. |

ii. **Distribution:** the connection will be established by means of distribution transformers, transmission voltage / distribution, located next to transmission substation. The entire installation will be defined as follows:
### Transmission installation

- Substation busbars connection points to the transmission system and all their points (connection of transmission and distribution elements to the substation).
- Installations to the power transformer regardless of the length of the connection, excluding the said connection, the surge diverters and connection elements between these and the transformer.
- Management (maintenance and operation) of the above.

### Non-transmission installation

Connection by means of transmission / distribution voltage power transformer.
- Distribution side substation.
- The power transformer or transformers, transmission / distribution voltage (including surge diverters and connection elements with the transformer).
- Management (maintenance and operation) of the above.

---

### iii. Qualified consumers: The installation will be defined as follows:

### Transmission installation

- Substation busbars connection points to the transmission system and all their points (connection of transmission and non-transmission elements to the substation).
- Connection by means of overhead line: complete position to the connection point of the line at the first substation point.
- Connection by means of a cable: complete position, to the connection cable terminal at the substation (the terminal is non-transmission).
- Connection by means of power transformer: complete position to the power transformer, excluding the said transformer, the surge diverters and connection elements between these and the transformer.
- Management (maintenance and operation) of the above.
<table>
<thead>
<tr>
<th>Non-transmission installation</th>
<th>Connection by line:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Qualified consumer side substation.</td>
</tr>
<tr>
<td></td>
<td>• Connection line or lines between non-transmission and transmission areas.</td>
</tr>
<tr>
<td></td>
<td>• Management (maintenance and operation) of the above.</td>
</tr>
</tbody>
</table>

Connection by means of transmission / non-transmission power transformer.

- Qualified consumer side substation.
- The power transformer or transformers, transmission / non-transmission voltage (including surge diverters and connection elements with the transformer).
- Management (maintenance and operation) of the above.
5. DESIGN AND EQUIPMENT REQUIREMENTS

The installations connected to the transmission system must be provided with the necessary elements to guarantee the normal operation of the electrical system and that it behaves as planned in exceptional situations.

5.1 Power equipment

Depending, among other criteria, on the distance between the transmission area and the non-transmission area, the link installation between both will be:

- **TYPE A**: Non transmission line without transformer (generation and qualified consumer connection).
- **TYPE C**: Via non-transmission transformer
  - **TYPE C1**: Generation and qualified consumer connection.
  - **TYPE C2**: Distribution connection.

The following figures describe the basic configurations for the link installations in the three main types, indicating the boundary between transmission and non-transmission, limits between areas, connection installation as defined in R.D. 1955/2000, link installation and name of the elements involved.

The purpose of these diagrams is to provide a conceptual identification of the boundary point between the transmission and non-transmission systems in the main connection systems to the transmission grid and to name the elements that will be referred to later.

Comments:

- These are simplified diagrams for information purposes aimed at identifying the main elements involved or that may be involved in the connection.

The single wire line of the transmission substation will be defined according to P.O. 13.3. It is represented in the diagrams as an example of a double busbar system, providing a simplified indication of the application for a one and a half breaker arrangement.
TYPE A

Parque transporte = Transmission area
Barras subestacion transporte = Transmission substation busbars
Instalacion de enlace = Link installation
Interruptor enlace lado transporte = Transmission side link switch.
Seccionador enlace lado transporte = Transmission side link isolator
Red Transporte = Transmission system
Red no Transporte = Non-transmission system
Linea = Line
Parque generacion/consumo = Generation/consumption area
Interruptor enlace lado generacion/consumo = Generation/consumption side link switch.
Seccionador enlace lado generacion/consumo = Generation/consumption side link isolator
Barras subestacion generacion/consumo (si existen) = Generation/consumption substation busbars (if relevant)
Aparamenta subestacion generacion/consumo (si existen) = Generation/consumption substation switchgear (if relevant)
Transformador generacion/consumo = Generation/consumption transformer
Interruptor generacion/consumo = Generation/consumption switch
Generador/Consumidor = Generation company/Consumer

TYPE C1 (lo mismo mas....)

Transformador no transporte = Non-transmission transformer
Parque no transporte = Non-transmission area
TYPE C2 (lo mismo mas....)

Parque distribución = Distribution area  
Interruptor enlace lado distribución = Distribution side link switch.  
Seccionador enlace lado distribucion = Distribution side link isolator  
Barras subestacion distribucion = Distribution substation

For the better clarification of the boundary between transmission and non-transmission for transmission substations with configurations that differ from the double busbar configuration displayed in the diagrams above, below we have included a diagram, as an example, that indicates the boundary point in cases where the transmission substation uses a one and a half breaker arrangement.
Parque transporte = Transmission area
Barras subestacion transporte = Transmission substation busbars
Interruptor enlace lado transporte = Transmission side link switch.
Seccionador enlace lado transporte = Transmission side link isolator
Red Transporte = Transmission system
Red no Transporte = Non-transmission system

Regardless of the solution adopted for the link installation, following the legal principle of separating activities, switches must be installed on both sides of the link installation (transmission side and non-transmission side).

The preferred solution for generation units will be a machine switch (generation switch in the images) and a non-transmission link switch on the generation side. One of the two switches
may only be eliminated in TYPE-C1 installations when the functions of the non-transmission link transformer and of the generation transformer are performed by the same device.

In the case of consumers directly connected to the transmission system, they may also eliminate one of the two switches, preferably the link switch, when the non-transmission transformer and the consumption transformer functions are performed by the same device.

The synchronization of the grid may not be performed by switches on the transmission system, unless an agreement is reached to synchronise via an island mode operation system or if an agreement is reached for cases where the said switches must be used for synchronization purposes; as in the case of pumping installations. See section 6.3 of this procedure.

If the link installation includes insulated line or cable, these will be designed in compliance with the design criteria included in P.O. 13.3 for transmission systems and previously accepted by the transmission company.

Link installations that comprise lines or cables with T connections will not be accepted.

If the link installation includes a non-transmission power transformer; this element will comply with the minimum requirements established in operational procedures concerning voltage and frequency conditions, protections, information on tap-changers and interface signals.

The transmission side of the power transformer will be star-shaped, with neutral rigidly connected to earth. In the case of generation installations, the generation side will be triangular. However, other connections may be accepted with the prior agreement of the system operator and the manager of the transmission system.

5.2 Protection systems

The protection system of a link installation and of an installation connected to the transmission system must comply, at least, with the contents of the document, “General Protection Criteria Governing the Spanish Peninsular Electricity System”, approved by the National Energy Commission and that includes requirements governing protection system equipment of
managed grids and connected installations. Additionally, the installation protection system will co-ordinate with the protection systems of the grid to which it connects.

Furthermore, the above-mentioned criteria will be applied to generation powers that, as a whole, exceed 50 MVA and share the link installation.

Additionally, the connection to transmission system installations via circuits/lines that are less than 9 kilometres long will require the protection of the said circuits by means of a differential protection for 2SP/1C equipment (double independent protection system and communications circuit) and double differential protection for 2SP/2C equipment (two independent protection systems and two independent communications systems). Communications, in the case of 2SP/1C will be applied to the differential protection and, in the case of 2SP/2C, each communications circuit will be applied to each differential protection.

Generation under the special regime must be adapted to the requirements established in current legislation on transmission system product quality, in line with the contents of section 3.1 of this procedure. It must also be able to support, without damage, any faults and relevant clearing time contemplated in the document “General Protection Criteria Governing the Spanish Peninsular Electricity System”.

Furthermore, generation under the special regime will not degrade the system variables when it is subject to distortions.

5.3 Auxiliary services

In compliance with legal criteria governing the separation of activities, there will be physical and functional independence between the alternating current and direct current auxiliary service equipment on the transmission system and the equipment on other grids. If, due to any reason, the said segregation were impossible to achieve, both parties must assess the possible alternatives that they agree will solve the problem.

While the installation served by the transmission installation is in service, it must have support from the non-transmission installation.

If the installation connected to the transmission system requests auxiliary electric power from the transmission substation, this will depend on availability; accepting the transmission company’s design specifications.

5.4 Grounding network

The design of the grounding network of the installations connected to the transmission system will be co-ordinated with connection point fault levels and with the grounding network of the transmission substation.
5.5 Communications Link with System Operator & Transmission System Manager

Operational procedure 9, “Information exchanged between the system operator”, includes the need to implement a communications link between the different elements of the Spanish electric system (including installations connected to the transmission system) and the Electric Grid control centres; either directly or through the control centres of the transmission companies and distributors, as well as the features of the said system. Equally, it establishes the measurements and signals to be exchanged.

Production companies under the special regime must also include signals to send to the receiving companies (owners of the grid they connect to) and distribution companies (with which they enter into technical-financial contracts).

5.6. Supervision

The conditions and development of access and connection processes of new installations to the transmission system or the alteration of existing processes, the increase in power and conditions declared in existing installations already connected to the said grid are included in P.O. 12.1.

The system operator and transmission system manager will supervise compliance with the design and equipment requirements.
6. OPERATIONAL CONDITIONS

6.1 Shared installations

When the owner of the connected installation requests permission to physically install the equipment required by Measurement regulations at the transmission installation, or if he needs to take any of the reference values to measure the power of the transmission equipment, a specific agreement among the parties must be reached.

The said agreement will be based on the following principles:

a) Maintain the maximum possible independence between own installations on the transmission grid and those assigned for other purposes.

b) The responsibility of the equipment required (whether main, redundant and verification equipment) for measuring the power provided to or consumed from the transmission grid will lie with the owner of the installations connected.

c) Any reference measurements taken related to equipment belonging to the transmission grid must not affect the scheduled maintenance of the said equipment in any way.

The request must be justified by the unavailability of alternative means to perform the measurements required by the regulations.

If equipment has to be installed in order to comply with Measuring regulations at the transmission installation, the transmission company, whenever possible, will install and maintain the required equipment, paid by the owner of the connected installations and on request of the said party, keeping them as physically and electrically independent as possible from other equipment owned by the transmission company assigned to specific transmission purposes. Although the cost of the equipment and the installations and the maintenance will be paid by the applicant, the features of the said equipment will be agreed by both parties, applying, as far as possible, criteria of uniformity concerning existing equipment on the transmission grid.

6.2 Maintenance

The maintenance programme of the transmission grid installations has been described in P.O. 3.4.

The maintenance of the link installations will be based on the criteria established by the transmission company, which may request any protocols and documents deemed necessary to verify compliance with the said criteria.

A prior condition for connecting to the grid will be an agreement between the transmission company and the agent covering the specific procedures concerning maintenance, duration and periodicity of discharges, access control and safety or any other aspect considered
necessary to ensure the correct operation of the installations. The said procedures will be prepared by the transmission company in co-ordination with the agent.

6.3. Handling

A prior condition for connecting to the grid will be that the transmission company and the agent have reached an agreement on specific procedures concerning handling or any other aspect that the transmission company considered necessary to ensure the correct operation of the installations. The said procedures will be prepared by the transmission company in co-ordination with the agent.

Transmission installations and those connected must include their own means that will enable them to control their own activities appropriately and, consequently, fulfil their responsibilities. In particular, the agent will appoint an interlocutor who will be available 24 hours a day and who will have the capacity for real-time decision-making concerning the link installation. The said interlocutor may be a third party contracted by the agent for this purpose.

The power generation installation must include at least one switch that operates as a machine switch. If the generation side link switch has not been installed, in the case of Type C1 installations, the owner of the generation installation may request a specific agreement with the transmission company concerning the operation of the transmission substation position that activates the connection. This situation will only be possible in cases where the generator has the possibility of operating in island mode in relation to its auxiliary services or when the synchronisation function can only be performed with the transmission grid that activates the connection. In any case, the decision to cede control of the transmission installation will always lie with the owner of the transmission installation.

The specific agreement will include all the technical and financial conditions required to ensure the service that are considered necessary by both parties (including, for example, unavailability times, consequences of incorrect operations due to equipment failure on the transmission grid that have been temporarily ceded, maintenance agreements, financial responsibilities for damage, insurance policies to be contracted, protection co-ordination, etc.).

On the other hand, and prior to the commissioning of the connection installations, the agent that is going to be connected, together with the Control Centre that operates the link installations, in the case of a third party, must sign a general handling agreement with the transmission company that owns the installations, which will specify:

Handling responsibilities for each position.

How to proceed under normal situations and in emergencies.

How to proceed in the case of work performed on the installation and in the case of accidental discharges.
How to proceed in the case of a voice communications breakdown between the control centres responsible for handling operations or if the remote control of the installations is lost.

Other issues included in the CTA and that affect the operation of the link installation.

The said general agreement will be formalised in the shape of a general procedure between the transmission company, the agent connected and the control centre responsible for operating the connection installations, in the case of a third party.

6.3.1. Generators with machine switch.

The machine switch is displayed as the “generation switch” in figures A and C1 in section 5.1.

Standard generator operations will be performed using the machine switch or the link switch on the non-transmission side, depending on the type of installation. The specific agreement will refer to the synchronisation from the island operation or when the synchronisation function may only be performed by the transmission grid position that activates the connection.

The elements required to perform the synchronisation process will be installed at the headquarters and will be owned by and be the responsibility of the generator.

The transmission company will provide the generator with the substation voltage signals and the central synchronisation elements will operate directly on the substation switches.

When the central office and the transmission substation are connected by means of a circuit; considering the installation a TYPE A installation, the synchronisation with the transmission grid will be via the link switch on the generation side (non-transmission). No specific agreements will be applicable in this case.

The handling of the link switches on the transmission side as transmission grid elements will have priority over the synchronisation of the generator when in island mode.

6.3.2. Generators without machine switch.

The only case where machine switches may not exist is in installations where there is a link switch on the non-transmission side of the link installation.

Standard generator operations will be performed using the non-transmission link switch located on the high voltage side of the generation or link transformer, depending on the installation. In this case, synchronisation will always be performed by this switch and, therefore, the specific agreement on the operation of the transmission side link switch will not be applicable.

The machine switch has been represented as the “generation switch” in figures A and C1 in section 5.1.
6.4. Connection and disconnection conditions.

The dispatching of the transmission and generation grids, as specified in each case, at the request of the system operator and manager of the transmission system, will be responsible for activating or inhibiting the remote tripping function of installations connected to the transmission system.

Power generation under the special regime will also include the following conditions:

1. The system operator and manager of the transmission system will have the power to establish a staged generation system to be connected per minute.

2. The system operator and manager of the transmission system will have the power to establish “emergency” disconnections.

3. Remote tripping may be implemented due to low power to specific consumers and in the event of any opening of the transmission substation switch.

The implementation of any of these conditions, or any others, included in the contract between the distribution side and the generators will affect, in most cases, the operation of the transmission positions in virtual boundary situations. Therefore, the transmission company may revise the said contracts and propose changes if necessary. In some cases, it may even be necessary to reach contractual commitments with the distribution company; of which the relevant Authorities must be notified.

This case may be extended to contracts established between commercialising companies and qualified consumers.
7. COMMISSIONING NEW INSTALLATIONS

Once the access and connection procedures have been completed and the technical access contract has been signed for the commissioning of any non-transmission installation connected to the transmission system; the approval of the system operator and manager of the transmission system will be required. This will be required whether in the case of a direct connection due to the commissioning of a link installation (whether one or several power generation installations or a distribution installation or a consumption installation), as in the case of integrating a non-transmission installation that is incorporated or modified and linked to a link installation that is already in service (whether due to a generation installation within a group of generating installations or a distribution installation or a consumption installation connected via a link installation that is in service). Equally, the commissioning of installations connected to the distribution grid that significantly affect the transmission system under the terms established in R.D. 1955/2000 under the standard generation regime and in R.D. 661/2007 for special regime generation, will be subject to approval by the distribution company and the system operator and manager of the transmission system, as established in R.D. 1955/2000.

When planning the commissioning of a new link installation to the transmission system (as defined in Article 5 of the present procedure); in the case of the first link with direct connection to the transmission grid, the company that owns the transmission system to which the new non-transmission installation is connected will inform on its operational programme in advance, at least two months, so that it can be integrated by the system operator and manager of the transmission system in the Annual Transmission System Maintenance Plan in accordance with operational procedure 3.4 “Transmission system maintenance planning”.

With this in view, the transmission company will notify the system operator and manager of the transmission system of the technical specifications of the link installation, more specifically of the following points:

- Commissioning programme and date.
- Single-wire diagram.
- Updated information on the installation in accordance with operational procedure 9 “Information exchanged by Red Electrica (Electric Grid Company)”.  
- Telephony, remote measuring, meters and remote control systems, etc.
- Initial commissioning plan, determining verifications and the sequence of operations required for bringing the installation into operation.
- Any other information of interest for the commissioning process.

When planning the energising and commissioning of the production installations, distribution installations or consumption installations and of connection installations linked to the above-mentioned non-transmission installations, connected to the transmission grid via the above-mentioned link installation and, if relevant, with connection to the distribution network that
significantly affects the transmission system, and at least two week in advance, the Power
Generator in the Standard Regime, the Single Node Interlocutor for generation under the
special regime, the manager of the distribution grid or the consumer, respectively, and the
manager of the distribution grid in the case of installations connected to the distribution grid,
should request authorisation to energise and commission the installation from the system
operator and manager of the transmission system; submitting the following information that will
enable the identification of the installations that are to be commissioned and, on the other
hand, indicate compliance with the requirements indicated below, in the format and on the
forms that the system operator provides for these purposes.

- Description of the installation that is to be commissioned:
  
  - Installations for which the Energising and Commissioning Authorisation is being
    requested.
  - Description of the installation (name, transformer number, etc.).
  - Linked node proposed by Transmission Grid (220 or 400 kV) (name and voltage).
  - Connection node to the Distribution Grid (Name and voltage), if relevant.
  - Test schedule and dates planned for commissioning for tests and the commercial
    operation or availability of the installation. In the case of power generation installations,
    provide information on active and reactive power use and generation forecasts during
    the tests.
  - Date of application for Energising and Commissioning Authorisation.

- Operational requirements prior to applying for the commissioning authorisation and that
  will be accredited in the said application:

  - Compliance with Measurement Points Regulations concerning the features of the
    measuring installation, measuring equipment verification, connection to the main
    concentrator and reception of boundary measurements on the measuring system in
    accordance with established procedures.
  - Updated information on the installation in accordance with operational procedure 9
    “Information exchanged by Red Electrica” in the format and on the forms provided by
    the system operator.
  - Commissioning of the real time measuring system.
  - In the case of production installations, assign them to a Generation Control Centre with
    connection to REE, provided with the technical and human infrastructure required to
    ensure its permanent operation and that provides reliable communications with Red
    Electrica in order to ensure compliance with existing limitations and receive real time
    operational instructions from its Control Centres.
  - In the case of distribution networks, there should be an authorised Control Centre
    provided with the technical and human infrastructure required to ensure its permanent
    operation and that provides reliable communications with Red Electrica in order to
    ensure compliance with real time operational instructions.
  - In the case of consumers, assign them to a Control Centre with connection to REE or
    agree on a procedure to co-ordinate operations with the system operator and manager
    of the transmission system.
In order to proceed to commissioning non-transmission installations linked to production installations under the Special Regime, and with a view to ensuring optimum use of the transmission system and to promoting co-ordination in relation to processing installations, a minimum generation level is required that must be installed simultaneously or with a guarantee of imminent installation. The said minimum level will be:

- 50 MW for 220 kV.
- 100 MW for 400 kV.

The imminent installation of a generation installation is understood to be within a maximum commissioning period of 2 months from the date of the commissioning of the associated connection installations, which should be proven and documented appropriately by the Single Node Interlocutor before the system operator and manager of the transmission system, including a statement by the relevant Administration.

Therefore, once the information has been received and compliance with all operational requirements has been verified and, if relevant, any minimum power requirements, the system operator and manager of the transmission system will issue the relevant commissioning authorisation for the connection installations associated to the production or consumption installations.

Furthermore, in the case of production installations, prior energising and commissioning authorisation must be requested for tests so that the operator may verify the system via the Electric Control Centre (CECOEL) or Special Regime Control Centre (CECRE) to ensure that the production control possibilities of the said installation comply with the requirements established. Consequently, the power generation company (or the Single Node Interlocutor) will provide the information indicated in the format and on the forms provided by the system operator.

After issuing the Commissioning Authorisation for the non-transmission installation, the system operator and the manager of the transmission system will plan the commissioning date for the said installation (particularly the link installation if it exists), respecting the dates proposes by the company that owns the transmission grid if there is no discharge or safety detriment for the grid. If this were not the case, the operator would propose the appropriate dates and conditions; notifying the applicant, in any case, within one month since the reception of the application. When commissioning generation installations that affect the transmission system and supply the distribution network, and once the Commissioning Authorisation has been obtained from the system operator, the date for commissioning will be established by the distribution system manager in co-ordination with the production installation.

If, once the commissioning date has been set, any situation should arise that implies the unfeasibility of the commissioning process for the dates proposed, the system operator and manager of the transmission system will propose, as soon as possible, a new date that is feasible from the point of view of the safety of the system.
From that moment, and once the commissioning date has been agreed, the system operator and manager of the transmission system will assess the convenience of calling a meeting with the parties involved to co-ordinate the commissioning schedule, which will specifically settle the following points:

- Discharges.
- Initial state of the grid before starting the commissioning process.
- Sequence of operations required and verifications in each commissioning phase.
- Final state of the grid once the commissioning process is over.
- Interlocutors for commissioning.
- Future operational conditions.
- Repercussion on Service Reclamation Plans (IRP files- Reclamation Plan Instructions – automatisms…)
- Compliance with previous requirements on the link installation and production, distribution or consumption installations.

This information must be updated as soon as possible each time changes are planned.

The Operational Plan for the commissioning process will consider the needs established by the agents and the safe operation of the system.

If discharges are required on the transmission system for the commissioning process, these will comply with standard procedures indicated in operational procedure 3.4. “Planning transmission system maintenance”. No short term discharges will be allowed for the sole purpose of commissioning an installation, unless the said discharge is due to an unforeseen delay of another discharge already requested in the Weekly Plan.

The effective commissioning of the link installation will take place in accordance with the plan prepared and in compliance with applicable safety procedures.

In the case of transmission installations, once the plan has been prepared and the voltage tests have been performed and the operation of the link installation has been verified, the installation will be ready for use, not forgetting the relevant administrative authorisation. Equally, in the case of non-transmission installations and once all tests have been performed, the owner will notify the system operator and manager of the transmission system and, if relevant, the manager of the distribution system, of the availability of the said installation for use. Equally, in the case of production installations, their state of availability will be announced with a view to performing production control tests.

If, during the tests any operational defects were detected in the link or non-transmission installation, the transmission company, in co-ordination with the owner of the non-transmission installation will proceed to repeat the tests once the defects detected have been corrected. No installation may be commissioned until all planned tests have been passed satisfactorily. Furthermore, if relevant, the system operator and manager of the transmission system will be notified of any changes to technical specifications introduced during the commissioning process, if applicable.
Furthermore, in the case of production installations that will be connected via a shared link installation with direct connection to the transmission system and regardless of whether the said installation is in service or not, commissioning and energising authorisation will be required for tests under the terms indicated for all individual or connection production installations that use the said link installation. This authorisation will enable the effective and individual execution of the connection process for production installations.

8. TECHNICAL REQUIREMENTS FOR PRODUCTION INSTALLATIONS

The present section establishes the technical requirements that must be fulfilled by power generation installations in order to guarantee they can be controlled and to ensure the safety of the electricity system.

With this in view, this section is applicable to:

- All power generation installations connected to the transmission system.
- All installations over 10 MW connected to a distribution network.

The technical requirements described below will be applicable to installations that are commissioned from 1st January, 2012.

In general, the technical requirements linked to values of electricity system variables must not be understood as adjustment values of installation protections. The said requirements must be understood as minimum technical specifications required during distortions and in permanent regimes. The adjustment of protections of installations provided with the technical capacity to support more extreme and long-term values of system variables than the minimum values required herein are based on the said features of the installation, avoiding adjustments to the minimum values required herein.

8.1. Definitions

The following definitions relate to this operational procedure:

Grid connection point

Node on the transmission grid or distribution network where the production of a generation installation is evacuated.

Centre busbars

Electric point where the liquidation measurement of the installation is performed.
Correctly cleared short circuit.

A short circuit in the electric system is understood to be correctly cleared when the protection systems have operated in accordance with operational procedure O.P. 11.1 “General Protection Criteria”.

Fault period

Time elapsed between the commencement of a short circuit –with a voltage dip below 0.85 p.u.– in the electric system and the instant when the said short circuit is cleared by the protection system designed for this purpose.

Voltage recovery period

Time between the instant of the appearance of distortion (in the event of short circuit it will be understood as the moment of clearing the fault) and the instant in which the centre busbars are again within the limits of the permanent regime indicated in figure 8.2.1a for a period of 30 seconds.

Nominal apparent power

This is the highest apparent power that the installation can supply constantly at the nominal voltage. This power is considered as the base of the installation for the purpose of expressing quantities in values per unit (p.u.).

Nominal intensity

The intensity corresponding to the nominal apparent power and the nominal voltage. This intensity is considered as the base of the installation for purposes of expressing quantities in values per unit (p.u.).

Active reference power ($P_0$)

This is the active power of the installation prior to the start of the distortion or, at any time, the maximum power corresponding to the instantaneous availability of the primary resource during the electric distortion and respecting the control ranges or maximum power limits, where applicable, assigned by the system operator during the prior permanent regime.

8.2 Production installations based on synchronous generators connected directly to the grid

The owner of the installation must adopt the design and/or control measures necessary to comply with the technical requisites described below, as well as those that could derive from the other operating procedures.

8.2.1. Operating ranges according to the electric system variables

The generation installation must be capable of remaining connected according to the voltage
(effective grounding voltage in centre busbars) and to the frequency during at least the time indicated in figure 8.2.1a:

Voltage (pu)
Apply the figure 8.2.1b
1 hour
Permanently
3 hours
30 minutes
Apply requisites indicated in the text

Frequency
(*) For nominal voltage of 400 kV, 440 kV is considered instead of 1.15 p.u.
(**) For nominal voltage of 400 kV, 435 kV is considered instead of 1.115 p.u.

![Diagram](image.png)

Figure 8.2.1a. Minimum time that the installation must be capable of supporting without disconnecting from the grid according to the voltage (in centre busbars) and to the frequency.

The generation installation will not disconnect because of activation of minimum voltage protections or for the failure of its automation and control systems (contactors, relays, etc.) where there are balanced or imbalanced residual voltage dips below 0.85 p.u. lasting less than 1 second.
Furthermore, the installation will be capable of remaining connected where there are surges (effective grounding voltage in centre busbars), in one or in all the phases, according to figure 8.2.1b.

Voltage (pu)  
Time (ms)

![Figure 8.2.1b. Minimum time of temporary surges in one or in all the phases of centre busbars that the installation must be capable of supporting without disconnecting.](image)

Figure 8.2.1b. Minimum time of temporary surges in one or in all the phases of centre busbars that the installation must be capable of supporting without disconnecting.

In this regard, the effects of the relevant protection of the installations must be stressed, as surges over 1.20 p.u. might occur in the electric system.

The installation will also be able to support the closing of the transmission system lines with an angular difference between poles of the line switch of 20°, and occasionally up to 30°.

No equipment in the installation may limit the natural capacity of the synchronous generators in order to support high temporary deviations in frequency. In view of this, the installations will support frequency deviations of, at least ±2 Hz/sec.

If the installation is connected to distribution grids and the receiver grid is equipped with the protection necessary for detecting operation in the island mode, said protections must coordinate with the provisos of this section for responding to voltage dips, surges and frequency deviation, in such a way that it guarantees that no disconnection will occur of the installation within the operating ranges defined herein.

8.2.2 Voltage control requisites

The installation will be able to perform a voltage inspection at the voltage and reactive power set points, both in centre busbars. The specific control mode will be indicated in real time by the system operator according to the operating conditions. The installation will be capable of implementing a change in the set point in real time.

The contribution of reactive power by the installation to the electric system in both the permanent and temporary regimes associated with a distortion will be done so that the
operating point is governed by an automatic voltage regulation system (known by its acronym “AVR”).

In addition, the installation must comply, in the permanent regime, with the following requisites:

- Within the voltage range $0.95 \leq V \leq 1.05$ p.u., the generation installations must have the technical capacity to generate and absorb reactive power ($Q$) in a minimum mandatory range and must modify their production and absorption of reactive power to these limits, so that they may collaborate in maintaining the voltage in the centre busbars within the admissible voltage ranges.

- The margin delimited by the generation/absorption of $\pm 15\%$ of the net active power installed ($P_{an}$), to the nominal voltage of centre busbars, is established as the minimum mandatory margin reactive power required in these busbars.

- These requisites will vary depending on the value of the voltage in the corresponding node of centre busbars in a range of $\pm 5\%$ around the nominal voltage according to the linear function indicated graphically in figure 8.2.2:

\[ Q(%P_{an}) = \begin{cases} \frac{30}{100}P_{an} & \text{for } V = 0.95 \\ \frac{15}{100}P_{an} & \text{for } 0.95 < V < 1.05 \\ \frac{0}{100}P_{an} & \text{for } V = 1 \\ \frac{-15}{100}P_{an} & \text{for } 1 < V < 1.05 \\ \frac{-30}{100}P_{an} & \text{for } V = 1.05 \\ \end{cases} \]

\[ Q_{\text{min}}(V) = \begin{cases} 0 & \text{for } V = 0.95 \\ \frac{15}{100}P_{an} & \text{for } 0.95 < V < 1.05 \\ \frac{0}{100}P_{an} & \text{for } V = 1 \\ \frac{-15}{100}P_{an} & \text{for } 1 < V < 1.05 \\ \frac{-30}{100}P_{an} & \text{for } V = 1.05 \\ \end{cases} \]

\[ Q_{\text{max}}(V) = \begin{cases} 30 & \text{for } V = 0.95 \\ 15 & \text{for } 0.95 < V < 1.05 \\ 0 & \text{for } V = 1 \\ -15 & \text{for } 1 < V < 1.05 \\ -30 & \text{for } V = 1.05 \\ \end{cases} \]

\[ V_{n} = \text{nominal voltage of centre busbars} \]

\[ P_{an} = \text{net active power installed} \]

**Figure 8.2.2 Minimum requisites of generation/absorption of reactive power according to the voltage in centre busbars.**

- This range of generation/absorption of reactive power must be capable of being provided to the installation for the entire variation range of the active power comprised between the minimum technical power and its net active power installed.

- Outside the voltage ranges where $0.95 \leq V \leq 1.05$ p.u. during the operation in permanent regime, the installation will inject/absorb reactive power depending on the voltage control response with the limitations that, because of being found outside said voltage range, are imposed by the production of active power, that is, the production of active power will take precedence over that of reactive power.
8.2.3. Power and frequency control requirements

The installation must be prepared to allow establishing the active power operation base in the entire range of possible powers from the technical minimum to the net active power installed at the request of the system operator for the purpose of being able to comply with the regulations on this matter set out in other Operational Procedures.

All the conventional synchronous generators must have available, at least, the power-frequency regulation equipment necessary to be able to provide the mandatory complementary service of the primary regulation under the terms set forth in O.P. 7.1.

Unless assessed to the contrary by the system operator, all the synchronous generators whose registered nominal power exceeds the 250 MW must incorporate a Power System Stabilizer (known by its acronym “PSS”) adjusted to appropriately damp the local oscillation mode as well as the predominant inter-area oscillation mode that the system operator will indicate.

8.2.4. Resetting the service

The new production units in ordinary regime corresponding to thermal technology, in view of distortion in the grid that could trigger the disconnection of the unit, must have operating capacity in the island over their auxiliary services.

The new installations of conventional hydraulic production and the reversible pumping centres in the ordinary regime must have, in the first as well as in the second group installed in each site, the capacity for autonomous starting and energization and regulation operating in island mode feeding market pockets. However, after agreement with the system operator and acceptance by the Ministry of Industry, Tourism and Trade (MITyC), the possibility is considered that the service could be provided in an alternative way, if this option is more advantageous for the subject and equally valid for the electric system, with hydraulic groups already existing in the same geographic area.

8.3. Wind farms and photovoltaic installations and in general all the production installations whose technology does not use a synchronous generator connected directly to the grid

The owner of the installation must adopt the design and/or control measures necessary so that the facilities comply with the technical requirements described below, as well as with those that may be derived from the other operational procedures.

Nevertheless and as an exception, different specific technical characteristics, although conceptually different to those required herein, can be admitted occasionally and alternatively, when they are equally valid for the electric system, and it may be agreed with the system operator and with the acceptance of the MITyC to allow when duly justified
certain flexibility in the application of these requirements and to avoid unnecessary modifications of this P.O.

8.3.1. Operating ranges according to the variables of the electric system

The generation installation must be capable of remaining connected in keeping with the voltage (effective grounding voltage in centre busbars) and with the frequency during, at least, the times indicated in figure 8.2.1a for synchronous generation.

Furthermore, the production installation and all its components must be able to support, without disconnection, any distortion in the voltage in centre busbars, produced by three-phase, two-phase grounding or single-phase short circuits or in view of any cause of another nature without occurrence of fault, with the profile values and duration shown in figure 8.3.1.

In the case of isolated two-phase grounding short circuits, the profile values and duration of the voltage dip in which the installation must be capable of remaining connected to the grid will be similar to that of figure 8.3.1, but with the lower voltage value being situated at 0.5 p.u. instead of 0 p.u. and at 0.6 p.u. instead of 0.2 p.u.

Voltage (pu)
Voltage prior to distortion
Starting point of distortion
Time (sec)

Figure 8.3.1. Voltage-time curve\(^1\) that defines the “voltage distortion” area in centre busbars that must be able to be supported by the installation. Phase-Grounding voltage corresponding to the distortion phases.

\(^1\) Voltage per unit: value expressed in per-unit basis with respect to the nominal voltage of the system.
For voltages in centre busbars less than 0.2 p.u. (0.6 p.u. in the event of isolated two-phase grounding faults), blocking is permitted in the power electronics (being able to leave the apparent current injected to the grid at zero). This blocking in the power electronics must be eliminated before 100 ms have transpired once the voltage exceeds the value of 0.2 p.u. (0.6 p.u. in the event of isolated two-phase grounding faults).

In addition, the installation will also be capable of remaining connected when there are surges in the terms set forth for the synchronous generation in figure 8.2.1b.

Blocking in power electronics is permitted (being able to leave the apparent current injected to the grid at zero) for voltages over 1.15 p.u. Said action must be eliminated before 100 ms have transpired once the voltage falls below the value of 1.15 p.u.

Although said blocking is permitted, it must be pointed out that for the effects of the relevant protection of the installations surges over 1.20 p.u. could appear in the electric system.

Similarly, the installation will be able to support, without short circuits, instantaneous angular variations of the voltage in centre busbars of at least 30º.

The system operator could require that, in the event of frequency surges, the installations disconnect with a lower frequency to that established as the technical capacity (figure 8.2.1.a) and with a certain timing in order to configure in this way the disconnection plans for maximum frequency.

The installations must also be able to withstand deviations in the frequency of at least ±2 Hz/sec.

If the installation is connected to distribution grids and is equipped with the protections necessary for the detection of island operation on the receiver grid, these protections must coordinate with the provisions of this heading for the response to the voltage dips, surges and frequency deviations, so that it may guarantee that no disconnection will occur in the installation within the operating ranges defined herein.

8.3.2. Voltage control requirements

The production installations must be able to participate in the control of the voltage of the electric system. For this supply they must comply with a set of requisites listed below. In order to improve the understanding of them, they have been separated into two subgroups, one for the permanent regime and another for the distorted regime in the event of the appearance of temporary under-voltages or surges.

8.3.2.1. Voltage control during the permanent regime

The installation will be able to perform voltage control at the voltage and reactive power or power factor set points, all in centre busbars. The installation will also be able to change the
specific control mode in real time, if this is required by the system operator according to the operating conditions. Moreover, the installation will be able to implement in real time a change in the voltage, reactive power or power factor set points.

Independently of the regulation mode (voltage, reactive power or power factor), the response speed will be such that the entire response required must be completed before 1 minute transpires. The absorption/injection capacity of reactive power will be such that it meets the aforementioned requirement for the synchronous generation in figure 8.2.2, modifying the value required of \( Q(\%P_{an}) \), in turn, according to the active power produced according to figure 8.3.2.1a.

\[ P_{an} : \text{net active power installed} \]

\[ Q>0: \text{reactive power injected to the grid} \]

![Diagram](image)

**Figure 8.3.2.1a. Minimum requirement of generation (absorption of reactive power \( Q \) in percentage of the net active power installed \( P_{an} \) according to the active power \( P \) generated (in percentage of the net active power installed \( P_{an} \)).**

For regimes operating below 10% of the net active power installed, the installation is exempted from meeting a minimum capacity in this regard; however, it will provide all the capacity that is possible.

In the control mode at the voltage set point, the installation must inject/absorb reactive power (\( Q \)) in the centre busbars according to the deviation of the voltage (deviation per unit with respect to the voltage set point) according to the indications of the figure 8.3.2.1b.

Slope \( K_v \)

Dead band
In addition, it will comply with the following requisites:

The slope ($K_v$) must be adjustable at least between the values of 0 and 25, with $P_{an}$ being the net active power installed and $V_{base}$ being the nominal voltage of the centre busbars.

The installation will have the capacity to adjust a dead band from zero to $\pm 0.01$ p.u. around the voltage set point.

Outside the voltage ranges where $0.95 \leq V \leq 1.05$ p.u., the installation will inject/absorb reactive power depending on the control response (voltage, reactive power or power factor set point), with the limitations that, because of being found outside said voltage range, are imposed by the production of active power, that is, the maintaining of programmed active power will take precedence over the injection/absorption of reactive power.

Subsequent to the commissioning, the system operator can require modifying, according to the evolution of the needs of the electric system, the operating values of the adjustable parameters described herein. The owner of the installation will have reasonable periods for implementing these modifications in said parameters.

8.3.2.2. Voltage control during the distorted regime

This control will commence its activity at the moment in which the effective voltage of the centre busbars goes out of the range of $0.85 \leq V \leq 1.15$ p.u., either because of under-voltage or surge and it will remain active during the distortion until the end of the voltage recovery period (see definition in section 8.1; however, the time indicated at lower values could be adjusted at the request of the system operator). Subsequently, it will return to the operating
regime prior to the distortion.

The installation must inject/absorb, depending on the voltage, a reactive current greater than or equal to that indicated in figure 8.3.2.2a. In order to determine this, the effective value of the direct sequence component of the voltage in the centre busbars will be used. In the event of imbalanced faults, this current can be injected through the three phases (direct sequence intensity) or only through the faulting phases, in which case similarly to a synchronous generator (direct sequence and reverse sequence), with the last option being preferable. The system operator, depending on the evolution of the electric system and of the needs that may arise, can give instructions to reduce the reactive current to inject, either at the general level or for specific installations. The owner of the installation will have reasonable periods to implement the necessary modifications in said parameters.

Within the voltage margin ±5% around the nominal voltage, the installation will have the same capacity to absorb/inject reactive power as in the permanent regime (section 8.3.2.1).

When the voltage is between 0.95 and 1.05 p.u., the production of reactive power of the installation will be similar to that corresponding to the permanent operation if a voltage control at the voltage set point is used, except for the response time. In the event that the control in permanent regime is at constant reactive power or at constant power factor, it will change to voltage set point using the voltage prior to the distortion as the set point.

Base of the nominal intensity

The D and D' points correspond to the injection/absorption capacity of reactive power of the installation in the permanent regime

Limit of the voltage below which the blocking of the power electronics is allowed

Limit of the voltage above which the blocking of the power electronics is allowed
Figure 8.3.2.2a. Injection/absorption of the minimum required reactive current “I_r” according to the voltage V

While the voltage control of distorted regime is active, for voltage below 0.95 p.u., the trend line of the evolution of the active current with the voltage will be between the limits established in figure 8.3.2.2b, with it being preferable that the current is as close as possible to the upper characteristic. In case of imbalanced distortion, this limitation applies to the three phases (direct sequence intensity) or only to the phases at fault, according to the type of control adopted, with the second being preferable. For voltages over 0.95 p.u., the maintaining of the active power of reference will prevail over the demand for injection of reactive current.

At the start of the distortion, the possible violation of the limits of the active current must be eliminated before 100 ms transpire.
In case of using blocking in the power electronics, the limits of active current will not be applied.
Figure 8.3.2.2b. Upper and lower limits of the active current “Ia” in unit values with respect to the nominal apparent power of the installation.

The response speed for the injection/absorption of reactive current, when blocking of the power electronics is not being applied, will be such that:

- The mean value of the reactive current injected to/absorbed from the grid in the first 100 ms (150 ms in the event that the voltage goes below 0.2 p.u. or 0.6 p.u. in the case of isolated two-phase faults) after the appearance of the distortion exceeds 60% of the reactive current injection demandable by the mean voltage existing during these 100 ms (150 ms) in accordance with figure 8.3.2.2a.

- After the 100 ms indicated above (150 ms in the event the voltage goes below 0.2 p.u.), 90% of the response required is reached in less than 40 ms. However, for effective voltages in centre busbars with the range $0.85 \leq V \leq 1.15$ p.u. reaching 90% of the response required in less than 250 ms is sufficient although, through common accord between the system operator and the promoter, a higher response time can be implemented.

8.3.2.3. Contribution of reverse sequence voltage

The production installations must contribute the reverse sequence current that, where applicable, the system requires. As the installation grows in the technologies that at present do not fulfil said need, the contribution of reverse sequence voltage will tend to be established as a future technical requisite.

The technologies that evolve towards the possibility of fulfilling said need prior to the establishment of a future requisite must perform the contribution of reverse current to the
system under the conditions that, where applicable, will be established, by means of a specific agreement with the system operator and acceptance by the MITyC.

8.3.3. Requisites of power and frequency control

The installation must allow establishing the base operating power in the entire route of feasible powers up to the maximum available in accordance with the primary energy resource at the request of the system operator for the purpose of being able to comply with the regulations in this regard in other Operational Procedures.

The installation will have the capacity to apply limitations to the value of the up or down ramps (not related to the decrease in the primary energy source) of the production. Said limitations to the ramps will be set by the system operator.

In the same way, the installation must be able to send to the system operator the measurement corresponding to the difference between the producible active power according to the primary energy source and the active power produced according to the set point received from the system operator.

8.3.3.1. Power-frequency regulation

If as a consequence of complying with Operational Procedure 7.1 (Primary regulation complementary service), mandatory for all the production units, the installation provides said service directly, it must have the technical capacity described in this section in order to maximise the production with these technologies.

This control could be activated and deactivated in real time at the request of the system operator depending on the need for participation of this generation in the power-frequency regulation.

The installation must be capable of increasing/decreasing its active power \( (P) \) according to the decrease/increase in frequency \( (f) \), complying with the indications of figure 8.3.3.1.

Band to raise
Slope K
Dead band
Band to lower
Figure 8.3.3.1. Unit increase of active power according to the unit deviation of the frequency.

It will also comply with the following requisites:

The slope (K) must be adjustable at least between the values of 15 and 50 with M_base being the nominal apparent power of the installation and f_base being the nominal frequency (50 Hz).

The response speed will be adjustable up to a maximum value of 10% of the nominal apparent power per second. The system operator can accept lower maximum response speed values to that required depending on the possibilities, where applicable, of contribution (or emulation) of the installation's inertial response. This latter possibility will be established, where applicable, through a specific agreement with the system operator.

The installation must be able to maintain the ΔP required for the control during at least 15 minutes (when the primary energy source so permits).

The installation will have the capacity of adjusting the dead band between ±10 mHz and ±200 mHz.

The control will be able to be temporarily disabled while the voltage is maintained below 0.85 p.u.

It must be capable of receiving in real time from the system operator and implementing reserve power set points to be raised or lowered, which could be different (for example, the band of set point to be raised is zero and that to be lowered is of a certain value), with the real reserves available at every moment having to return to the same level:

- The installation must modify its operating point according to the variability of the primary resource in order to ensure the availability of the reserve band to be raised.

- Notwithstanding the above, the installation will be exempt from the provision of the band to be raised when its production is less than 20% of the nominal power of the installation and it will be exempt from the provision of the part of the band whose
application decreases the power below 20% of the installation's nominal power.

The system operator will communicate, depending on the evolution of the needs of the electric system, the operating values of the adjustable parameters described herein.

8.3.3.2. Emulation of inertia

The generation installation can have the capacity to emulate inertia. The inertial contribution is necessary for the system to the extent that the synchronous generation is moved through the new technologies based on power electronics.

The conditions in which this capacity could, where applicable, be provided will be established by means of a specific agreement with the system operator and acceptance by the MITyC.

8.3.3.3. Damping the power oscillations in the system

The generation installation could have the capacity to damp oscillations of power of an electromechanical origin in the system when beneficial for the oscillatory stability of the electric system.

The conditions in which this capacity could, where applicable, be provided will be established by means of a specific agreement with the system operator and acceptance by the MITyC.
Appendix I. Conditions for distortion measurement in the transmission system

For the purpose of being able to monitor the distortions introduced by potentially distorting loads to those that supply the service, and to require the performance of corrective actions if the established limits are reached, below are listed the conditions that must be met in order to make these measurements.

For the definition of said conditions, the UNE-EN and CEI 61000-X-X [1] [2] [3] [4] [5] series have been used.

**Voltage imbalance**

In order to compare the measurements with the established limits, CEI 61000-3-6 [1] is used. The measurements must be made in periods with a minimum duration of one week, and the following must be verified:

- The maximum 95% daily value measured with a very short integration period (3 seconds) must not exceed the limits of very short duration established in this procedure.

- The maximum weekly value measured with a short integration period (10 minutes) must not exceed the limits of short duration established in this procedure.

- The maximum weekly value measured with a very short integration period (3 seconds) must not exceed the limits of very short duration established in this procedure multiplied by 1.5.

**Harmonics**

The measurements must be made in periods of a minimum duration of one week following the recommendations of the CEI 61000-3-6 [1] and UNE-EN 61000-4-7 [5]. The following must be verified:

- The maximum 95% daily value measured with a very short integration period (3 seconds) must not exceed the limits established in this procedure.

- The maximum weekly value measured with a short integration period (10 minutes) must not exceed the limits established in this procedure.

- The maximum weekly value measured with a very short integration period (3 seconds) must not exceed the limits established in this procedure multiplied by 1.5.

**Flicker**

In reference to flicker, the measurements must be made following the conditions specified in
the UNE-EN 61000-4-15 [4] standard and taking into account the points made in CEI 61000-3-7 [2].

References


