## 9.2 Rate of change of frequency (ROCOF) protection

This standard does not require rate of change of frequency (ROCOF) protection in an *IBR plant*. In cases where ROCOF protection is used to protect specific equipment within the *IBR plant*, it shall not impede the *IBR plant* from meeting the ride-through requirements of this standard inclusive of ROCOF ride-through requirements. ROCOF should be based on a change of frequency averaged over sufficient time to reject spurious frequency measurements caused by distortion and transients.

## 9.3 AC voltage protection

Any applied IBR voltage protection shall allow the *IBR plant* to meet its ride-through requirements. The *TS owner* and the *IBR owner* shall coordinate the *IBR plant* voltage protection with the TS voltage protection, if present, and the undervoltage load shedding (UVLS) scheme in the area.

All instantaneous overvoltage protection used within the *IBR plant* shall use filtered quantities (Schweitzer and Hou [B105]) to reduce the possibility of misoperation while providing protection to the desired equipment and system. Any instantaneous overvoltage protection(s) that has the possibility of disrupting the power output of the entire plant shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the TS. Protection margin shall be coordinated with the *TS owner*, wherever applicable.

Where instantaneous overvoltage protection is applied on *IBR unit*(s), it shall:

- Be coordinated with transient overvoltage capability of *IBR units*
- Be coordinated with any surge protection implemented within the *IBR plant* and at the RPA
- Allow the *IBR plant* to meet its transient overvoltage ride-through requirements specified in 7.2.3

## 9.4 AC overcurrent protection

AC overcurrent protection is applicable to phase and sequence quantities. This standard does not require overcurrent protection for every piece of equipment in an *IBR plant*. However, if an *IBR owner* employs this protection element, then it shall not limit the facility's ride-through capability as required in this standard and shall be coordinated with other protection schemes that are applied on the TS, while maintaining adequate protection in the *IBR plant*.

All instantaneous overcurrent protection used within the *IBR plant* shall use filtered quantities (Schweitzer and Hou [B105]) to minimize the possibility of misoperation while providing protection to the desired equipment and system. Any instantaneous overcurrent protection(s) that has the possibility of disrupting the power output of the entire plant shall use at least one cycle (of fundamental frequency) measurement window to reduce such possibility and the related impact on the TS. The ac overcurrent protection shall be coordinated with the *TS owner*, wherever applicable.

## 9.5 Unintentional islanding protection

Any unintentional islanding protection schemes used by the *IBR units* or the *IBR plant* shall not limit the *IBR plant*'s ride-through capabilities specified in this standard.[136]

[136] *IBR units* may use inbuilt active unintentional islanding protection schemes to protect themselves and equipment in the *IBR plant*, for example, when any part of an *IBR plant*'s *collector system* becomes isolated due a fault inside the *IBR plant*.

If islanding of the *IBR plant* with any portion of the TS is not allowed by the *TS owner,* unintentional islanding protection shall be implemented, in accordance with the *TS owner* requirements.

### 9.6 Interconnection system protection

The *IBR plant* shall implement protection for the *interconnection system* in accordance with the requirements of the *TS owner* and/or the requirements of the owners of electrically joined facilities. This protection shall be coordinated with the TS protection system. Protection schemes shall not limit the *IBR plant*'s ride-through capability with the following exceptions:

— Faults within the *interconnection system*

— Faults within protection zones identified by the *TS owner* that provide sole connectivity of the *IBR plant* to the TS

— Faults within the *IBR plant* that cannot be cleared except by disconnecting the *IBR plant*

## 10. Modeling data

Some performance requirements, such as voltage ride-through performance requirements, for which the RPA is at the *point of measurement* (POM), cannot be verified based on type tests or production tests of individual equipment within an *IBR plant* and/or commissioning tests of the *IBR plant*. The *IBR plant* design evaluation using models and simulations is necessary to verify, to the extent feasible and possible, that the *IBR plant* meets performance requirements, especially during various stages of *interconnection studies* and commissioning. As detailed in 12.2.3, the *IBR plant* design evaluation may be performed by the *IBR owner, TS operator, TS owner,* third-party consultants, or jointly by these parties. It is critical that models provided for *IBR plants* are accurately structured and parameterized as well as reflect the actual installed equipment in the field for reliability study purposes and to help ensure reliability of the BPS. In addition to the *IBR plant* design evaluation, models are also necessary to perform various system studies.

It should be noted that almost all forms of models, even detailed EMT (electromagnetic transient) models of *IBR plants*, invariably have certain necessary approximations and limitations. For example, even in an EMT model, the full *collector system* details are almost never modeled for various reasons. Thus, no model can predict with absolute certainty the response of every individual *IBR unit* inside the *IBR plant*. As such, the results of simulations should be understood in this context. As an example, fault ride-through tests performed in simulations may show the entire plant rides through, while in real life the exact same event may result in a small number of *IBR units* tripping in a plant with tens or hundreds of *IBR units*. This is because the *collector system* is typically equivalenced and even if it were modeled in all its details, one cannot predict the exact status (e.g., wind speed at each turbine) of each *IBR unit* for a given condition. In short, modeling is not, nor will it ever be, perfect. For approximations that are made while developing the models, a technical reference that provides the relevant background and justification should be cited. If such a reference(s) is not available, a detailed explanation related to the said approximations should be provided. In either case, the resultant model should be shown to provide a verified behavior.

Upon request from the *TS operator* and *TS owner,* the *IBR owner* shall provide:

a) Verified *IBR plant*–level models, including a steady-state power-flow model, positive-sequence (fundamental-frequency)[137] stability dynamic model[138] (user written[139] and/or generic[140]), an EMT model, short-circuit and harmonics models, to perform *IBR plant* design evaluation and system studies. If necessary, the *TS operator* and *TS owner* may request additional types of models from the *IBR owner* with proper justification.

b) Documentation detailing development process and verification of these models.

c) Documentation with brief explanation of control strategy.

Some common practices to develop verified models is outlined below, but may vary among original equipment manufacturers (OEMs). The *TS owner* or *TS operator* may specify model verification methodology for interconnecting *IBR plants*.[141]

— Non-aggregated *IBR unit* EMT model—This model may be developed based on actual code and may be verified with type and/or hardware-in-the-loop (HIL) test results.[142]

— Supplemental equipment, including *supplemental IBR device,* EMT model—This model is verified with type and/or HIL test results.[143]

— Aggregated plant-level EMT model—The *IBR unit* EMT model and EMT models of any supplemental equipment within IBR facility is used to develop the aggregated plant-level EMT model. The *collector system* within the IBR facility can be represented with an equivalent.

— *IBR unit* stability[144] dynamic (user written and/or generic), short-circuit, etc., models—This model is verified against non-aggregated *IBR unit* EMT model. This model includes converter and respective electrical control models.

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[137] The major stability planning software tools presently used in North America, and many other places in the world, use phasor (fundamental-frequency) representations, with the transmission network modeled as a constant impedance matrix, such that the lumped impedance of all passive elements is provided as the effective positive-sequence (fundamental-frequency) impedance. These tools are referred to as positive-sequence (fundamental-frequency) programs. There are, however, some software tools that go one step further and model the network in greater detail, allowing full sequence representation for three-phase phasor (fundamental frequency) analysis. In both these cases, the dynamics models for the controllers and devices being discussed are essentially the same. The primary difference is in the way the network model is developed and interacts with the dynamic model. Finally, note that positive-sequence (fundamental-frequency) modeling tools are sometimes called “RMS” tools, but that is not an accurate description and is not used as a description or label for such simulation tools in this standard.
[138] The *TS operator*, *TS owner*, *IBR owners,* and OEMs are encouraged to work jointly to determine the type of model (user-written, generic, or both) for an *IBR plant* design evaluation. Although the scope of this requirement is for *IBR plant* design evaluation only, the need of models for various local and interconnection-wide system studies should also be considered.
[139] The user-written model contains more specific, nuanced control information than a generic model. The user-written (and presumably more detailed) model may be necessary for the interconnection process. The *TS operator* and *TS owner* need to know how the IBR functions in the transient time frame, especially when concerned about a very specific, focused area.
[140] The generic model is usually used for interconnection-wide studies because the focus is on the entire interconnection. Accuracy may be compromised due to generic nature of the model. It may not be possible to map all the parameters of generic models to actual controls and protection settings. If so, the IBR owner, the respective OEM(s), *TS owner,* and *TS operator* are encouraged to jointly work to identify and document any shortcomings of the generic model.
[141] This standard specifies *what* type of validated and verified models be provided in the interconnection process. IEEE P2800.1 or IEEE P2800.2 that are under development at the time of this standard’s adoption may specify *how* the model validation and verification methods be conducted.
[142] It is likely that a certain type (vintage, model, etc.) of converter and respective controls are used in multiple products. For example, a WTG with active power rating ranging from 4.0 MW to 5.0 MW may use the same converter. If so, a verified EMT model of this converter may be used to represent all WTGs that utilize this converter. A similar approach could also be used for inverters in PV solar and battery energy storage system (BESS)–based resources.
[143] Due to the size and custom design nature of HVDC and some FACTS and other large converters, model verification based on type tests, prior to commissioning, is not possible. Even during the commissioning, it is not possible to perform all necessary dynamic performance tests, since such tests cause severe stress on the ac network. Therefore, dynamic performance tests and model verification are usually done by HIL tests with original converter control hardware. A highly reliable EMT model could be produced by using an actual control code implemented in a hardware in conjunction with, or instead of, HIL test results. The use of an actual control code in EMT models may allow for reduction in the number of HIL tests that otherwise needs to be conducted to produce a verified model.
[144] *Stability model* refers to models used in fundamental-frequency positive-sequence software platforms for stability analysis.

— The plant controller aspect of the stability model is typically verified or calibrated with plant commissioning test results.

In case of an *IBR plant* to be built in the future, it is understood that as-built verified models only become available once the *IBR plant* is built or closer to being commissioned. However, during the interconnection process, the *IBR owner* shall make every effort possible to provide credible models to *TS owner* and *TS operator* for various studies.

During the interconnection process or once the *IBR plant* is operational, modifications to controls that change the response of the *IBR plant* or *IBR units* as defined within this standard shall be mutually agreed upon between *TS operator*/*TS owner* and the *IBR owner*. The *IBR owner* shall provide updated models to *TS owner* and *TS operator* according to a schedule determined by the *TS owner* or *TS operator*.

Once the *IBR plant* is operational, system event data could be used to verify various plant-level models. When suitable event data are available and used to verify plant-level models, it is expected that the performance of the *IBR plant* during an event may not exactly match with the one observed in simulations.[145] If so, engineering judgement is necessary in determining if the *IBR plant* meets the performance requirements of this standard. In case where simulated performance of the *IBR plant* does not closely match with the performance observed during an event as mutually determined by *IBR owner* and *TS owner*/*TS operator,* the *IBR owner* shall provide updated models to *TS owner* and *TS operator* according to a schedule determined by the *TS owner* or *TS operator.*

Depending on the type of study and the level of modeling required, different types of modeling data are required. Annex G provides a list of the data recommended in each category of models.

## 11. Measurement data for performance monitoring and validation

To aid with performance monitoring, event analysis, and disturbance-based model validation (NERC Reliability Guideline [B75]), the *IBR plant* shall take measurements at specified points throughout the resource, from individual *IBR units* to the POM, using various technologies available. The data type, measurements/data point, recording rate, duration of those data, and retention of those data are specified in Table 19. Except for any confidential data in the "inverter fault codes and dynamics recordings" category as defined in this clause, the *IBR owner* shall make these data available to the *TS owner*/*TS operator,* for event analysis, performance monitoring or model validation. Availability of the excepted "inverter fault codes and dynamic recordings" data to the *TS owner*/*TS operator* shall be by mutual agreement. Where this excepted data are not made available to *TS owner*/*TS operator,* the *IBR owner* shall perform their own analysis of significant TS events as requested by *TS owner*/*TS operator* and share findings with the *TS owner*/*TS operator*. The *IBR plant*'s operational measurement data for exchange with *TS operator, load balancing entity, regional reliability coordinator,* and markets in which it operates to facilitate integration in the electric system is specified in 4.6.

It is expected that the regional regulatory requirements require the *IBR owner* to report any unplanned change in operating and/or control mode to the *TS operator* in a timely manner.

All measured data, including status log of plant equipment (breakers, transformers, reactive compensation devices, etc.) shall be time synchronized to Coordinated Universal Time (UTC). Time synchronization design is discussed in IEEE Std 2030.101™. All *IBR plant*–level monitoring devices (sequence of event recorder, digital fault recorder, dynamic disturbance recorder, and power quality meter) shall be synchronized to UTC with ± 1 µs time accuracy, preferably using IEEE 1588–compliant devices, that implement either the IEEE C37.238 or IEC/IEEE 61850-9-3 application profiles intended for the utility industry. Alternatively, time synchronization using technologies based on unmodulated IRIG-B may be applied, but requires additional

[145] For model verification using an event data, the grid and *IBR plant* should match pre-event operational conditions to the extent possible in simulations.

implementations beyond standard IRIG-B to achieve specified level of time accuracy. The *IBR unit*–level monitoring devices shall be synchronized to UTC with ± 100 µs time accuracy.

Where applicable, all collected data should follow requirements of the IEEE Standard Common Format for Transient Data Exchange (COMTRADE) or the IEEE Power Quality Data Interchange Format (PQDIF). COMTRADE files shall be provided as specified in IEEE Std C37.111™-1999, IEEE Std C37.111™-2013, or later.[146] PQDIF files shall be provided as specified in IEEE Std 1159.3™-2003 or IEEE Std 1159.3™-2019, or later.

The measured data shall meet requirements specified in 4.4 as noted in Table 19.

[146] A single file with a CFF extension should be provided instead of multiple component files to facilitate better management and archiving of data.

**Table 19—Measurement data—type, points, sampling rate, retention and duration**

| Provision data type | Measurement/data points (as applicable) | Recording rate | Retention | Duration | Measurement (as applicable) |
|---|---|---|---|---|---|
| Plant SCADA data (CSV file) | The plant SCADA system is often a lower resolution repository of information that, at minimum, shall include the following data points:<br><br>Measurements<br>— *Point of measurement* voltage and medium-voltage *collector system* voltages<br>— *Point of measurement* frequency<br>— *IBR plant* active and reactive power output<br>— *IBR units* active and reactive power output of individual[147]<br>— Shunt dynamic device reactive power output<br><br>Signals<br>— External control signals from the *TS operator* (BA, RTO, RC, etc.)<br>— External automatic generation control signals<br>— Active and reactive power commands sent to *IBR units* | One record per s | 1 year | One year | Subclause 4.4, Table 1 |
| Plant equipment status (tabular log file) | — All breaker statuses, including change of status log<br>— Shunt (dynamic or static) reactive compensation device statuses<br>— Substation transformer status (main step-up and *collector system*)<br>— Status of on load tap changer<br>— Medium-voltage *collector system* statuses<br>— Status of individual *IBR units*<br>— Time stamp<br>— Time synchronization (e.g., GPS status word) or status of the GPS clock signal | Static, as changed | 1 year | NA | Not applicable |

[147] Variables like commands may be only recorded when the value is changed and not at a specified sampling rate.

**Table 19—Measurement data—type, points, sampling rate, retention and duration *(continued)***

| Provision data type | Measurement/data points (as applicable) | Recording rate | Retention | Duration | Measurement (as applicable) |
|---|---|---|---|---|---|
| Unit functional settings | — *IBR unit* autonomous functions parameter settings[148] | Static, as changed | 1 year | NA | Not applicable |
| Sequence of events recording (SER) data (tabular log file, time tag shall have an accuracy of one millisecond or less) | SER devices should be sized to capture and store hundreds or thousands of event records and logs. SER event records can be triggered for many different reasons but at minimum, shall include the following:<br>— Event date/time stamp (synchronized to common reference, e.g., Coordinated Universal Time [UTC])<br>— Event type (status changes, synchronization status, configuration change, etc.)<br>— Sequence number (for potential overwriting) | Static, as changed | 90 days | NA | Not applicable |
| Digital fault recording (DFR) data (COMTRADE format and tabular log file) | This data shall be captured for at least the plant-level (e.g., at the *point of measurement*) response to BPS events. It is typically high resolution (kHz) point-on-wave data (transient) and triggered based on configured settings. Data points shall include:<br>— Time stamp<br>— Phase-to-ground voltage for each phase<br>— Bus frequency (as measured/calculated by the recording device)<br>— Each phase current and residual or neutral current<br>— Calculated active and reactive power output<br>— If applicable, dynamic reactive device voltage, frequency, current, and power output<br>— Applicable binary status | ≥ 128 samples per cycle, triggered | 90 days | 5 s COMTRADE data, (split between pre-fault and post-fault data needs to be mutually agreed upon with the *TS owner*/*TS operator*) | Subclause 4.4, Table 2 |

[148] For *IBR units* that use standardized settings specified in IEEE Std 1547-2018, the IEEE 1547.1/EPRI specified "Common File Format for DER Settings Exchange and Storage" [B18] may be used.

**Table 19—Measurement data—type, points, sampling rate, retention and duration *(continued)***

| Provision data type | Measurement/data points (as applicable) | Recording rate | Retention | Duration | Measurement (as applicable) |
|---|---|---|---|---|---|
| Dynamic disturbance recorder (DDR) data (COMTRADE format and tabular log file) | A DDR shall capture the specified plant-level data continuously at the *point of measurement*. This data can be used for multiple purposes including event analysis and disturbance-based model verification. Data points shall include:<br>— Time stamp<br>— Bus voltage phasor (phase quantities and positive-sequence)<br>— Bus frequency<br>— Current phasor (phase quantities and positive-sequence)<br>— Calculated active and reactive power output | Input: ≥ 960 samples per s output: ≥ 60 times (records) per s, continuous[149] | 1 year | NA[149] | Subclause 4.4, Table 2 |
| Inverter fault codes and dynamic recordings (CSV file and tabular log file) | For grid BPS faults/events which trigger ride-through operation of an *IBR unit* or cause it to trip, the following information shall be recorded at *IBR units* for analysis:<br>— All major and minor fault codes<br>— All fault and alarm status words<br>— Change of operating mode<br>— High- and low-voltage ride-through<br>— High- and low-frequency ride-through<br>— PLL loss of synchronism<br>— DC current and voltage<br>— AC phase currents and voltage<br>— Pulse width modulation index (if applicable)<br>— Control system command values, reference values, and feedback signals | Many kHz, triggered | 90 days | 5-s data, (split between pre-fault and post-fault data needs to be mutually agreed upon with the *TS owner*/*TS operator*) | Stated by *IBR owner* |
| Power quality—flicker (PQDIF format) | Plant-level $P_{st}$ and $P_{lt}$ using a flicker meter that is compliant with IEC 61000-4-15 and IEC 61000-4-30 | 10 min | 90 days | NA | IEC 61000-4-30 |

[149] A DDR with continuous data recording and storage capability is required. However, if the *TS owner* allows a DDR which records based on triggers then triggered records shall be at least of 3 min. The record triggers (i.e., frequency, voltage etc.) shall be based on mutual agreement between the *TS owner* and the *IBR owner*.

**Table 19—Measurement data—type, points, sampling rate, retention and duration *(continued)***

| Provision data type | Measurement/data points (as applicable) | Recording rate | Retention | Duration | Measurement (as applicable) |
|---|---|---|---|---|---|
| Power quality—RVC (PQDIF format) | Plant-level RVC (DeltaV/V) using a PQ meter that is compliant with IEC 61000-4-30 (IEC RMS value measured by one cycle, updated every half cycle) | NA | 90 days | NA | IEC 61000-4-30[150] |
| Power quality—Very short-term harmonics (COMTRADE or PQDIF format) | Plant level, both voltage and current harmonics as applicable (total distortion and individual harmonics up to order 50). Unless required by the *TS owner*, very short-term harmonics measurements are optional. | 3 s | 10 days | NA | IEC 61000-4-7 and IEC 61000-4-30 |
| Power quality—short-term harmonics (COMTRADE or PQDIF format) | Plant level, both voltage and current harmonics as applicable (total distortion and individual harmonics up to order 50). | 10 min | 90 days | NA | IEC 61000-4-7 and IEC 61000-4-30 |
| Power quality—long-term harmonics (COMTRADE or PQDIF format) | Plant level, both voltage and current harmonics as applicable (total distortion and individual harmonics up to order 50). | 95 weekly percentile<br><br>(per IEEE Std 519) | 1 year | NA | IEC 61000-4-7 and IEC 61000-4-30 |

[150] The rapid voltage change algorithm should satisfy the requirements specified in IEC 61000-4-30:2015/AMD1:2021 or later.

# 12. Test and verification requirements

## 12.1 Introduction

This clause specifies the test and verification requirements and methods applicable to each IBR interconnection and interoperability requirement specified in Clause 4 through Clause 11. This clause further specifies at which stages in the interconnection process testing and verification shall be required.[151] The applicable test and verification methods from this clause are required for all IBRs. The results of these test and verification methods shall be formally documented.

## 12.2 Definitions of verification methods

### 12.2.1 General

All IBR interconnection and interoperability requirements of this standard shall be verified by a combination of the following methods as specified in this clause: *type tests,* IBR evaluations, commissioning tests, and operational evaluation.[152]

Details of which verification method(s) apply to which requirements are specified in Table 20. These verification methods may apply to *IBR plants*, *IBR units*, and/or *supplemental IBR devices* used to meet the respective requirements.

### 12.2.2 Type tests

A *type test*[153] may be performed on one device or a combination of devices. *Type tests* shall be performed on *IBR units* as well as *supplemental IBR devices* that are used to meet the requirement of this standard as specified in Table 20.[154]

NOTE—*Type tests* are rarely, if ever, applied to entire *IBR plants*. The *IBR unit* type test results may not be directly used to verify ride-through capability requirements; however, they may be needed because the type test results may be used to develop an *IBR plant*–level model which may be used in the *IBR plant* design evaluation to verify requirements.

In cases where a *supplemental IBR device* is used to meet a requirement of this standard as specified in Table 20, the *type test* for such device in combination with other information on this device shall provide sufficient information to render possible verification during the design evaluation (see 12.2.3) of that specific requirement and any other requirement(s) for which conformance of the *IBR plant* to this standard may be impacted by that *supplemental IBR device*. The details of *type tests* are not provided in this standard, and may be provided by other standards, including by referencing existing standards as appropriate.

[151] This standard specifies *what* verification methods shall be used and *when* these apply in the interconnection process. It is expected that IEEE P2800.1 and IEEE P2800.2 will specify *how* these verification methods will be implemented, including the specification of test and evaluation procedures along with their pass/fail criteria. The applicability of IEEE Std 2800, IEEE P2800.1, or IEEE P2800.2 are determined by the AGIR for the location (IEEE P2800.1 and IEEE P2800.2 are presently under development and are designated IEEE P2800.1 and IEEE P2800.2 prior to approval).
[152] Development of dedicated type test procedures complementing this standard is recommended. Existing type test procedures, such as IEEE Std 1547.1-2020 [B51], IEC 61400-21-1 [B37], FGW TR3 [B24], FGW TR4 [B25], FGW TR8 [B26], IEC 62927 [B41], IEEE Std 115 [B49], IEC 60034-4-1 [B31], or IEC TS 60034-16-3 [B43], may or may not be appropriate to verify compliance with this standard. Certification of equipment, for example, under UL 1741 SA [B108], UL 1741 SB [B109], or UL 1741 CRD PCS [B107] is outside the scope of this standard.
[153] Refer to 3.1 for the definition of *type test*.
[154] Almost all of the performance requirements of this standard apply at the POM or POI, and thus type tests will not be able to fully verify compliance with this standard, but will serve to provide information useful to making this determination based on the design evaluation. Such information may include verified *IBR unit* and *supplemental IBR device* models as specified in Clause 10.

*IBR units* and *supplemental IBR devices* that are too large or have power ratings too high to be practically type tested may demonstrate conformance through other means.[155]

*Type tests* shall be performed on a representative *IBR unit* or subsystem[156] that represents the behavior of the IBR, either in the factory, at a testing laboratory or on equipment in the field. *Type test* procedures shall be designed to comprehensively verify relevant aspects of performance under simulated conditions (electrical and mechanical). *Type test* results from an *IBR unit* within a product family of the same design, including hardware and software, shall be allowed as representative of other *IBR units* within the same product family with different power ratings provided the hardware and software designs are appropriately scaled but not otherwise different between models.

While many of the requirements that are verified or partially verified through type testing apply at the POM, type testing typically is applied at the POC of the device under test. Thus, *type tests* and subsequent verification steps that use *type test* results as input shall take into account differences in conditions between POC and POM, and shall consider the aggregate behavior of the multi *IBR unit* and *supplemental IBR device* differences and responses.

For systems in the field, replacement of *IBR plant* components with substitutive components that have been verified compliant with this standard shall be allowed and not invalidate previous *type tests*. Field demonstration of compliance shall be agreed with the *TS operator*.

### 12.2.3 Design evaluation

The design evaluation (desk study) is an engineering evaluation during the interconnection and plant commissioning process to verify that the *IBR plant*, as designed, or the *IBR unit*(s), as applicable, meet the interconnection and interoperability requirements of this standard. The *IBR plant* design evaluation may be performed by the *IBR owner, TS operator, TS owner,* third-party consultants, and/or jointly by these parties. The design evaluation often includes modeling and simulation of the *IBR plant,* its *IBR unit*(s), and *supplemental IBR device*(s), and the interactions with the TS. This evaluation does not include testing. However, reports derived from test results may be consulted in the design evaluation, and the model verification may be informed by the results from *type tests* if available. The design evaluation may also determine other verification steps that may be required, such as commissioning testing or post-commissioning monitoring. The details of interconnection review process vary among *TS owners*/*TS operators* and may be dependent on regional regulatory requirements.

In cases where a *supplemental IBR device* may be used to provide *IBR plant* or *IBR unit*(s) conformance with a subset of requirements of this standard, the design evaluation shall be specific to such requirement(s) along with any other *IBR plant* or *IBR unit* requirement(s) for which conformance to this standard may be impacted by that *supplemental IBR device*.

### 12.2.4 As-built installation evaluation

The *IBR plant* as-built installation evaluation (on-site) is an evaluation at the time of commissioning to verify that *IBR units,* the *collector system, supplemental IBR device*(s), and *protective functions* forming an *IBR plant* as delivered and installed meets or exceeds the design as defined in the *IBR plant* design evaluation.

[155] For example, VSC-HVDC units, FACTS units, very large power electronic converters.
[156] An example of a subsystem that represents the behavior of the IBR can be a solar inverter or generator-inverter combination in the case of type IV wind turbine. The subsystem selected may be dependent on the type test performed and shall be the components used in the IBR product. The subsystem selected shall be in agreement between the IBR manufacturer and verification entity.