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| Load Compliance Assessment against Technical Rules  Report Template  [Facility Name - Size]    16 April 2024 |

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Load Compliance Assessment against Technical Rules

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Contents

[Important Notice v](#_Toc164167694)

[Instructions for using this Template vi](#_Toc164167695)

[Abbreviations vii](#_Toc164167696)

[1. Executive Summary 1](#_Toc164167697)

[1.1 Model Data Assessment 1](#_Toc164167698)

[1.2 Technical Rules Compliance Assessment 1](#_Toc164167699)

[2. Introduction 2](#_Toc164167700)

[3. Study Scope and Methodology 3](#_Toc164167701)

[4. Model Data Assessment 4](#_Toc164167702)

[4.1 Submitted Documents & References 4](#_Toc164167703)

[4.2 Model Description 4](#_Toc164167704)

[4.3 System Source Impedance 4](#_Toc164167705)

[4.4 Model Assessment - Generator and Load Model Guidelines 4](#_Toc164167706)

[4.5 Model Aggregation 11](#_Toc164167707)

[4.6 Flat Run 11](#_Toc164167708)

[5. Performance Assessment 12](#_Toc164167709)

[5.1 Technical Rules Requirements for Connection of Loads 12](#_Toc164167710)

[5.2 Performance Assessment Outcome 14](#_Toc164167711)

[5.2.1 Power Oscillation Damping – (TR Clause 2.2.8) 14](#_Toc164167712)

[5.2.2 Short Term Voltage Stability (TR Clause 2.2.9) 14](#_Toc164167713)

[5.2.3 Temporary Over-voltages (TR Clause 2.2.10) 14](#_Toc164167714)

[5.2.4 Fault Contribution (TR Clause 3.2.1) 14](#_Toc164167715)

[5.2.5 Excessive Fluctuations or Reactive Power Draw – (TR Clause 3.4.2(c)) 14](#_Toc164167716)

[5.2.6 Power Frequency Variations (TR Clause 3.4.3) 14](#_Toc164167717)

[5.2.7 Power Frequency Voltage Variations (TR Clause 3.4.4) 15](#_Toc164167718)

[5.2.8 Power Factor Requirements (TR Clause 3.4.7) 15](#_Toc164167719)

[5.3 Non-Compliance to Technical Rules Requirements 16](#_Toc164167720)

[6. Results Summary 17](#_Toc164167722)

[7. References 18](#_Toc164167726)

[**Appendix A** 19](#_Toc164167727)

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Document Information

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Important Notice

Purpose

Western Power has prepared this report Template to assist Accredited Service Providers in developing a Load Compliance Assessment against Technical Rules report on behalf of Customers with guidance on the required structure of the report submission.

Instructions for using this Template

Accredited Service Providers must submit a Load Compliance Assessment against Technical Rules report that is consistent with the format presented in this template.

Red text in this template report contains explanatory notes to assist Accredited Service Providers in providing the required information, red text must be removed from report prior to the submission of the Load Compliance Assessment against Technical Rules report to Western Power.

*Italicised* text contains examples and must be removed from report prior to the submission of the Load Compliance Assessment against Technical Rules report to Western Power.

Abbreviations

The following table provides a list of abbreviations and acronyms used throughout this document. Defined terms are identified in this document by capitals.

|  |  |
| --- | --- |
| Term | Definition |
| PoC | Point of Connection |
| SWIS | South West Interconnected System |
| TR | Technical Rules |
| … | … |

# Executive Summary

[Provide project background (including the ASP and Customer name) and summary of results per example Table 1.1. All information in the below subsections is to be provided by the Accredited Service Provide (ASP) unless approved otherwise by Western Power.

If applicable, ASP (provide name) to provide summary of facility non-compliance(s) to the Technical Rules per example Table 1.1. ASP/Customer to propose an adequate solution to rectify non-compliance(s) and consult Western Power for feedback on the adequacy of the proposed solution and further guidance.]

ASP (name) on behalf of the Customer (name) has completed the Load Compliance Assessment against Technical Rules of the facility (name) connecting to [location] [PoC voltage] in [load area name] Load Area of SWIS.

## Model Data Assessment

[Provide a summary of model data assessment outcome in Section 4]

## Technical Rules Compliance Assessment

[Provide a compliance assessment outcome summary in a format consistent with example Table 1.1.]

Table .: Compliance Assessment Summary

| Clause | Clause Description | Model Assessment Outcome |
| --- | --- | --- |
| **Generator and Load Model Guidelines** | | |
| 2.5.1 | Initialisation without warning/error | ✅ Compliant |
| - | Flat-run (no Disturbance) | ✅ Compliant |
| **Technical Rules** | | |
| 2.2.8 | Power Oscillation Damping | ✅ Compliant |
| 2.2.10 | Temporary Over-Voltages | ✅ Compliant |
| 3.2.1(f) | Fault Levels (Rating & Contribution) | ✅ Compliant |
| 3.4.2 (c) | Excessive Load Fluctuations, Reactive Power Draw and motor stall | ✅ Compliant |
| 3.4.3 | Immunity to Power Frequency Variations | ✅ Compliant |
| 3.4.4 | Immunity to Power Frequency Voltage Variations | ✅ Compliant |
| 3.4.7 | Power Factor Requirements | ✅ Compliant |

# Introduction

*ASP (provide name)* on behalf of the Customer (name) has completed the Load Compliance Assessment against Technical Rules report of facility (name) connecting to [location] [PoC Voltage] in [load area name] Load Area of South West Interconnected System (SWIS). The assessment methodology, criteria and outcomes of the compliance assessment are presented in this report.

# Study Scope and Methodology

Western Power has provided the ASP (name) with the maximum and minimum system source impedance at Point of Connection (PoC) to facilitate the development of a Load Compliance Assessment against Technical Rules report. The study is performed to assess whether the load model meets the required performance criteria and technical requirements. Models meeting the required performance criteria and technical requirements are deemed acceptable for integration into the SWIS Model to facilitate Network Studies in the next stage of the assessment process.

*ASP (name) has:*

* + 1. *Prepared a Load Compliance Assessment against Technical Rules report including the facility model for review and approval by Western Power.*

*The Report addresses the following requirements:*

* + - 1. *Model data assessment based on the documentation submitted during the Access Application.*
      2. *Model compliance with respect to the performance requirements stipulated in the Technical Rules [1] and the Generator and Load Model Guidelines [2].*
      3. *Compliance assessed against Technical Rules Clauses*

1. *Clause 2.2.2: Steady State Power Frequency Voltage*
2. *Clause 2.2.8: Power Oscillation Damping*
3. *Clause 2.2.9: Short Term Voltage Stability*
4. *Clause 2.2.10: Temporary Over-Voltages*
5. *Clause 3.2.1(f): Fault Levels (Rating & Contribution)*
6. *Clause 3.4.2(c) Excessive Load Fluctuations, Reactive Power Draw and motor stall*
7. *Clause 3.4.3: Immunity to Power Frequency Variations*
8. *Clause 3.4.4: Immunity to Power Frequency Voltage Variations*
9. *Clause 3.4.7: Power Factor Requirements*

# Model Data Assessment

[ASP to provide a single file package of all technical references and documentation in support of the submission. ASP to ensure submitted technical references and documentation is representative of the facility, PowerFactory model and study report.

Refer to Technical Rules [1] Attachment 3 and Western Power’s Generator and Load Model Guidelines [2] for details of supporting information.]

## Submitted Documents & References

The following documents and references are included by Customer (name) in support of the submission.

Table .: Submitted Documentation & References

| Item | Title/File name | Description |
| --- | --- | --- |
|  |  |  |

## Model Description

[Provide facility model single line diagram, aggregated and detailed]

[Describe the topology of the aggregated and detailed model]

## System Source Impedance

[Provide the source impedance at Point of Connection as provided by Western Power]

Table .: Point of Connection Source Impedance

| Short-circuit Case | PoC Nominal Voltage  (kV) | Three-Phase short-circuit, (MVA) | Three-Phase short-circuit, (kA) | R1 | X1 | R2 | X2 | R0 | X0 | X1/R1 |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Maximum |  |  |  |  |  |  |  |  |  |  |
| Minimum |  |  |  |  |  |  |  |  |  |  |

## Model Assessment - Generator and Load Model Guidelines

[Provide a summary of the Load Compliance Assessment against Technical Rules outcome with respect to the requirements of the Generator and Load Model Guidelines.]

*Table 4.3 denotes a summary of the results of the load model assessment with respect to the requirements of Western Power’s Load And Generator Model Guideline [2].*

Table .: Example Summary of Model Assessment per Generator and Load Model Guidelines

| **Item** | **Model Requirement** | **Criteria Met? (Yes/No/TBC)** | **Comments/ Action Items** |
| --- | --- | --- | --- |
| 1 | The model must be in native unencrypted DIgSILENT PowerFactory format suitable for use in the version of PowerFactory currently used by Western Power and suitable for integration with the Western Power model of the South West Interconnected System (“SWIS”). | Yes |  |
| 2 | The model must align with the site single line diagrams, and include relevant network data including auxiliary loads, transformer tap-changer and winding connection information. | Yes |  |
| 3 | The main slot(s) must be defined so that the model can be removed from service by taking the relevant generator out of service, without the need to also take the dynamic controllers out of service. | Yes |  |
| 4 | The model must represent the performance of the equipment under steady state and disturbance conditions. | Yes |  |
| 5 | Overhead transmission lines should be modelled using geometric tower models and conductor data. | Yes |  |
| 6 | All motors with a rating of 1 MW or greater must be modelled explicitly.  Motors with a rating of 5 MW or greater must have harmonic current emissions, mechanical characteristics of the drive load and total mechanical inertia parameters modelled. | Yes |  |
| **Steady-State Model Requirements** | | |  |
| 7 | The model must be suitable for balanced and unbalanced power flow studies, and for calculation of balanced and unbalanced short-circuit currents using 'Complete' and 'IEC' short circuit calculation methodologies. | Yes |  |
| **Dynamic Model Requirements** | | |  |
| 8 | The model must be represented in standard Laplace block diagram format to the extent possible. Use of any “black boxes” encrypted code or external DLL’s is not acceptable. Use of DSL expressions to represent functions that could otherwise be represented by standard blocks should be avoided. | Yes |  |
| 9 | The model must resemble the physical design of the equipment and controllers to allow Western Power to assess the suitability of proposed settings. | Yes |  |
| 10 | Model settings must align with the settings shown on the block diagrams provided with the Access Application. | Yes |  |
| 11 | Where a controller uses input measurements or control outputs, these must be appropriately configured and identified on the functional block diagrams. | Yes |  |
| 12 | The model functional block diagrams must illustrate all derivative states including derivative state variable names consistent with the block diagrams. | Yes |  |
| 13 | All required control and output signals should be available for dynamic (RMS) simulations and clearly illustrated on the model block diagrams. These signals can typically include but are not limited to the following: - Active and reactive power - Machine and Exciter current and voltage  - Other signals depending on the technology type. | Yes |  |
| 14 | The control mode and droop settings must be configured according to the usual operation and configured for both steady-state and dynamic simulations. | Yes |  |
| 15 | The model must include all functional controllers and ancillary equipment that materially affect the performance of the equipment over the typical timeframes of a dynamic simulation (up to several minutes), and accurately represent the performance for all possible conditions where the equipment would be in operation. | Yes |  |
| 16 | The model must illustrate all input and output signals including set-point signals on the model block diagrams and model frames and must clearly illustrate the interconnection of the various functional controllers. | Yes |  |
| 17 | The model and functional block diagrams must clearly illustrate whether limits are windup or non-windup and provides details as to which state variable is limited and the relationship between the limit values and state variable that is being affected by that limit. | Yes |  |
| 18 | Inclusion of multiple (unique) equipment control functions within a single macro block definition should be avoided. | Yes |  |
| 19 | The number of lines of code within a single macro block definition - excluding parameter definitions, initial conditions and comments – should generally not exceed 30. The intent of this requirement is to provide guidance to the model developer and to improve macro code readability and model usability (it is not intended to result in increased complexity of macro equations or detract from macro code readability) | Yes |  |
| 20 | The model must show all relevant non-linearities, such as limits, arithmetic or mathematical functions, events, dead bands and saturation. | Yes |  |
| 21 | The model must include descriptions of any arithmetic or mathematical functions, such as protection events or ride-through sequences. | Yes |  |
| 22 | The model should include relevant protection relays and settings to simulate the performance of the facility during power system disturbances. This includes, but is not limited to, under and overvoltage protection, under and over-frequency protection, etc. | Yes |  |
| 23 | The model must show all controller settings and settings ranges. Non-configurable settings should be identified on the functional block diagrams. | Yes |  |
| 24 | The model must identify any internal integration algorithms | Yes |  |
| 25 | The model must identify the characteristic of lookup table interpolation (e.g. spline, linear). | Yes |  |
| 26 | The model must automatically initialise its parameters from power flow simulations without errors. | Yes |  |
| 27 | When the model is opened and executed with the PowerFactory software version used by Western Power, it must not result in initialisation or run time warnings and errors, and there must not be any interactions or conflicts with other models. | Yes |  |
| 28 | Where the equipment has the capability to respond per phase, a full three-phase model must be provided. | Yes |  |
| 29 | Dynamic model parameters should have parameter names, descriptions and units defined in the DIgSILENT Simulation Language (DSL) models, for example "Kp Proportional gain [pu]. | Yes |  |
| 30 | The PowerFactory DSL model must compile to C code without warnings or errors. | Yes |  |
| 31 | Dynamic model initialisation must be invariant to simulation start time (i.e. not require the simulation to be initialised at a particular time). | Yes |  |
| 32 | Where parameters need not be recalculated at each time step, the DSL commands selfix(), limfix() and outfix() must be used instead of select(), limits() and output() so that they are only calculated at initialisation. | Yes |  |
| 33 | When the model is integrated into the SWIS model it must not result in interactions or conflicts with other models. | Yes |  |
| 34 | The model must support time domain simulations of the equipment for balanced and unbalanced conditions with a minimum integration step size of 0.002s. | Yes |  |
| 35 | The model must not include algorithms that require use of a particular integration step size (for example the model should not fail to solve, or the response be materially different for an integration step size of 0.001s). | Yes |  |
| 36 | Time constants less than 5 millisecond should only be included if their inclusion is critical to the performance of the dynamic model and are required to meet the accuracy requirements. | Yes |  |
| 37 | Internal integration algorithms should only be included if their inclusion is critical to meeting the accuracy requirements and should not materially detract from model simulation speed performance. | Yes |  |
| 38 | For unbalanced disturbances the response of each of the phases must be observed. | Yes |  |
| 39 | Non-convergence warnings can appear during some simulation events, however they may indicate issues with dynamic model, have an adverse impact on simulation to collapse. Non-convergence warnings should be minimised, and their causes may need to be investigated and addressed. | Yes |  |
| 40 | The model must be numerically stable for all possible ranges of system strength (short-circuit ratio and X/R ratio) where the generating system would be in operation. | Yes |  |
| 41 | The model must meet the accuracy requirements set out in the Load And Generator Model Guideline [2] | Yes |  |
| 42 | The methodology for aggregating loads and reticulation system demonstrating the equivalence between the detailed and aggregated models must be provided.  As a minimum, this must illustrate the alignment of power flow results and time domain simulation overlays of the facility at the PoC, for voltage, active power and reactive power for zero-impedance fault studies. | Yes |  |
| **Small-Signal model requirements** | | |  |
| 43 | The model must be capable of being executed in eigenvalue studies using both the QR method and Arnoldi method without modification. | Yes |  |
| 44 | All modes must have positive damping | Yes |  |
| **Other model requirements** | | |  |
| 45 | Unless there is a specific requirement for an EMT model, the ASP shall determine the degree PowerFactory model accuracy required to ensure the model and response is an adequate representation of the facility. | Yes |  |
| 46 | Where applicable, station controller and power-frequency controller are provided for all the applicable mode of operations. | Yes |  |

## Model Aggregation

The detailed model and the aggregated model were subjected to both a single phase to ground fault and three phase fault at the PoC with maximum protection fault clearance times per Technical Rules [1] (Provide graphical evidence of overlays for both models). The results of the detailed and aggregate model are overlayed confirming the aggregated model is an accurate representation of the detailed model, and the results are within the required accuracy criteria.

## Flat Run

[Provide summary of load model’s response to different voltage source set points (0.90 p.u, 1.0 p.u, 1.1 p.u) at Point of Connection (PoC) and present the simulation results.]

The model does not produce warnings and/or errors during initialisation. For all flat run study cases that contain no simulation events (parameter events, faults etc), voltage, power and frequency results remain constant[[1]](#footnote-2) throughout the simulation period as shown in [Provide reference to graphical evidence].

The results confirm the model meets the flat run criteria in all demand ranges for all operating voltages, typically 0.90 p.u, 1.0 p.u and 1.1 p.u at the PoC.

# Performance Assessment

## Technical Rules Requirements for Connection of Loads

[ASP to list all Technical Rule clause requirements assessed in the Model Assessment study report.]

Table .: Example of Technical Rules Requirement for Connection of Loads

| Clause | Clause name | Clause description |
| --- | --- | --- |
| 2.2.8 | Power Oscillation Damping | Technical Rules clause 2.2.8(a) requires the damping ratio of electromechanical oscillations must be at least 0.1.  Clause 2.2.8(b) for electro-mechanical oscillations as a result of a small disturbance, the damping ratio of the oscillation must be at least 0.5.  Clause 2.2.8(c), in addition to the requirements of clauses 2.2.8(a) and 2.2.8(b), the halving time of any electro-mechanical oscillations must not exceed 5 seconds. |
| 2.2.9 | Short Term Voltage Stability | Surviving an initial disturbance and reaching a satisfactory new steady state. |
| 2.2.10 | Temporary Over-voltages | As a consequence of a credible contingency event, the power frequency voltage at all locations in the power system must remain within the over-voltage envelope shown in Figure 2.1 in TR. |
| 3.2.1(f) | Fault Levels (Rating & Contribution) | A User connected to the transmission system may not install or connect equipment at the connection point that is rated for a maximum fault current lower than that specified in the connection agreement in accordance with clause 2.5.7(a).  A User connected to the distribution system, who is not a small use customer, must not install equipment at the connection point that is rated for a maximum fault current lower than that specified in clause 2.5.7(b) unless a lower maximum fault current is agreed with the Network Service Provider and specified in the connection agreement.  Where a User's equipment increases the fault levels in the transmission system, responsibility for the cost of any upgrades to the equipment required as a result of the changed power system conditions will be dealt with by commercial arrangements between the Network Service Provider and the User. |
| 3.4.2 (c) | Excessive Load Fluctuations, Reactive Power Draw and motor stalling | A Customer does not cause excessive load fluctuations, reactive power draw or, where applicable, stalling of motor loads that would have an adverse impact on other Users, System Management, the Network Service Provider or the performance of the power system.  A Customer does not cause any reduction of inter-regional or intra-regional power transfer capability based on frequency stability or voltage stability. |
| 3.4.3 | Power Frequency Variation | A Consumer must ensure that the equipment connected to its connection point is capable of continuous uninterrupted operation (other than when the facility is faulted) if variations in supply frequency of the kind described in clause 2.2.1(c) occur. |
| 3.4.4 | Power Frequency Voltage Variation | A Consumer must ensure that the equipment connected to its connection point is capable of continuous uninterrupted operation (other than when the facility is faulted) if variations in supply voltage of the kind described in clause 2.2.2 occur. |
| 3.4.7 | Power Factor Requirements | Power factor requirements to be met by loads connected to the transmission system and those connected to the distribution system rated 1 MVA or more are defined in Table 3.3 of the Technical Rules[1]. |

## Performance Assessment Outcome

### Power Oscillation Damping – (TR Clause 2.2.8)

[Provide summary of load model’s response to simulated disturbance (Single Contingency) at Point of Connection and present the simulation results.

The results parameters shown in the graphs should include; Voltage, Active Power, Reactive Power and Frequency at PoC and load terminal, the active power amplitude values to denoted on the graph to facilitate calculation of the damping ratio as show in below Figure 5.1.]

### Short Term Voltage Stability (TR Clause 2.2.9)

[Provide summary of load model’s response to simulated voltage disturbance and assess post-fault voltage recovery at Point of Connection and present the simulation results.

The results parameters shown in the graphs should include Voltage, Active Power, Reactive Power and Frequency at PoC and load terminal.]

### Temporary Over-voltages (TR Clause 2.2.10)

[Provide summary of load model’s response to simulated over-voltage excursions at Point of Connection and present the simulation results per voltage envelope specified in Fig. 2.1 of Technical Rules [1].

The results parameters shown in the graphs should include Voltage, Active Power, Reactive Power and Frequency at PoC and load terminal.]

### Fault Contribution (TR Clause 3.2.1)

[Provide summary of load model’s prospective fault contribution to maximum 3-phase short-circuit current at PoC which shall be consistent with prospective fault level declared in Application Assessment data, equipment ratings, and supporting technical references.]

### Excessive Fluctuations or Reactive Power Draw – (TR Clause 3.4.2(c))

[Provide summary of load model’s response to disturbance (Single Contingency) at Point of Connection and present the simulation results.

The results parameters shown in the graphs should include Voltage, Active Power, Reactive Power and Frequency at PoC and load terminal.]

### Power Frequency Variations (TR Clause 3.4.3)

[Provide summary of load model’s response frequency excursions at Point of Connection as specified in Clause 2.2.1(c) of Technical Rules [1] and present the simulation results.

The results parameters shown in the graphs should include Voltage, Active Power, Reactive Power and Frequency at PoC and load terminal.]

### Power Frequency Voltage Variations (TR Clause 3.4.4)

[Provide summary of load model’s response and ability to remain connected at voltage ranges of 90% to 110% of the nominal voltage at the Point of Connection and present the simulation results.

The results parameters shown in the graphs should include Voltage, Active Power, Reactive Power and Frequency at PoC and load terminal.]

### Power Factor Requirements (TR Clause 3.4.7)

[Provide summary of load model’s response to power factor requirements as specified in Table 3.3 of Technical Rules [1] and present the simulation results.

The results parameters shown in the graphs should include Voltage, Active and Reactive power of the load as measured at Point of Connection]



**Figure 5.1: Example of active power oscillations with amplitude values annotated**

## Non-Compliance to Technical Rules Requirements

[If applicable, should a facility load model fail to meet the performance criteria of Technical Rules clause(s), the non-compliance(s) must be stated and include supporting results. ASP/Customer to propose an adequate solution to rectify non-compliance(s) and consult Western Power for feedback on the adequacy of the proposal and further guidance.]

# Results Summary

[Provide summary of Load Compliance Assessment against Technical Rules results against all Technical Rules clauses specified in Section 5.1 with reference to the PowerFactory model to be provided]

# References

1. Technical Rules, Western Power 1st December 2016 (Rev 3), <https://www.erawa.com.au/electricity/electricity-access/western-power-network/technical-rules/technical-rules>
2. Western Power Generator and Load Model Guidelines, <https://www.westernpower.com.au/media/4738/generator-and-load-model-guidelines-20210125.pdf>
3. Department of Commerce (Energy*Safety*) – WA Electrical Requirements, 2019 <https://www.commerce.wa.gov.au/sites/default/files/atoms/files/waer_2019.pdf>
4. Western Power Access and Queuing Policy, <https://westernpower.com.au/media/1428/application-queuing-policy.pdf>
5. Electricity Networks Access Code (2004), <https://www.treasury.wa.gov.au/uploadedFiles/Site-content/Public_Utilities_Office/Regulatory_framework/ElecNetworksAccessCode.pdf>
6. Customers connection applications
7. Customers Works Planning Report (WPR)
8. Customers IPC
9. 1. Single Line Diagram(s)

[Provide single line diagrams as required.]

* 1. All Referenced Simulation Plots

[Provide referenced simulation plots for all study results.]

1. State changes in RMS models or fluctuations in RMS and EMT model responses should not be present during flat run assessments. [↑](#footnote-ref-2)