* 1. **Sünkroonmoodulite vastuvõtukatsete kava**

**Test 1. Measurements for determination generator parameters (can be replaced with factory acceptant tests)**

| **no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Open Circuit Saturation**  **This test is to measure generators Open Loop Characteristic** | **Measurement of the steady state variation of generator field current versus generator stator voltage from the minimum achievable generator stator voltage to at least 1.05 p.u. of the rated stator voltage with the generator circuit breaker open.** | **For machines with brushless exciters the field current measurement shall be the field current of the exciter** |
| **2** | **Saturation factors.**  **This test is to determine the generator saturation factors S1.0 and S1.2** | **The unit will be brought to synchronous speed and disconnected from the power grid with no field current. The field current will then be increased in steps of 10% until the generator armature voltage reaches 1.2 p.u. of the rated value. The generator armature voltage (Vt), field voltage (Vf) and field current (If) will be recorded, in tabular form, at each step.** |  |
| **3** | **Synchronous Machine Impedances and Time Constants Tests that reasonably confirm the d-axis reactances (Xd, X’d, X”d) and time constants (T’do and T”do) of the synchronous generator** | **For example, recording of terminal voltage and field current following opening of the generator circuit breaker with the generator running at near-zero real power and under-excited so as to absorb substantial reactive power with the excitation system in manual field voltage control**  **Details to be proposed by the manufacturer** |  |
| **4** | **Short circuit load test** | **Details to be proposed by the manufacturer** |  |

**Test 2. Power quality measurements**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Power quality measurements** | **Normal operation of power plant** | **Measurement period is 7 days.**  **initial conditions determined by Elering** |

**Test 3. Inertia.**

| **Part No** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Inertia.**  **A test that reasonably confirms the inertia constant of the turbine-generator, governor droop and other model parameters** | **The unit circuit breaker shall be opened to disconnect the unit from grid**  **Details to be proposed by the manufacturer.** | * **The machine is loaded to a small amount of MW (around 10 - 20% to prevent the interference from protection relay operation) and Mvar value (under-excited condition preferred).** * **The AVR is set in auto control mode and the governor in speed droop control mode.** * **The unit circuit breaker input signal to the turbine controller is blocked to defeat the machine speed preset.** |

**Test 4. Generator AVR testing.**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Step change to AVR voltage reference with the generating unit on open circuit** | **(a) +2.5 %**  **(b) -2.5 %**  **(c) +5.0 %**  **(d) -5.0 %**  **(e) +10.0 % (0,95pu to 1,05 pu)**  **(f) -10.0 % (1,05pu to 0,95 pu)** | **nominal stator terminal voltage** |
| **2** | **Manual variation of generating unit open circuit voltage** | **Stator terminal voltage (Ut)**  **(a) increase from 0.5 pu to 1.1 pu**  **(b) decrease from 1.1 pu to 0.5 pu**  **see notes below** | * **in 0.1 pu step for Ut between 0.5-0.9 pu** * **in 0.05 pu step for Ut between 0.9-1.1 pu** |
| **3** | **steady state over-excitation limiter (OEL) operation** | **Mvar outputs at OEL setting slow raising of excitation to just bring OEL into operation.**  **See notes below** | * **100% MW output** * **75% MW output** * **50% MW output** * **25% MW output** * **min. MW output** |
| **4** | **steady state under-excitation limiter (UEL) operation** | **Mvar outputs at UEL setting** **slow lowering of excitation to just bring UEL into operation.**  **See notes below** | * **100% MW output** * **75% MW output** * **50% MW output** * **25% MW output** * **min. MW output** |
| **5** | **Step change of Mvar on the transmission system**  **Test conducted by Elering** | **Switching in and out of:**  **(a) a transformer**  **(b) a reactor**  **(c) a capacitor** | * **parallel transformers on staggered taps** * **others as determined by Elering** * **test with and without PSS** |

| **6** | **Step change to AVR voltage reference with the generating unit connected to the system.**  **(PSS out of service)**  **Generating unit output levels:**  **(i)50% rated MW, and**  **(ii)100% rated MW** | **(a) +1.0 %**  **(b) -1.0 %**  **(c) +2.5 %**  **(d) -2.5 %**  **(e) +5.0 %**  **(f) -5.0 %**  **repeat (e) & (f) twice**  **see notes below** | * **nominal stator terminal voltage** * **unity power factor or underexcited operation** * **system base load OR typical conditions at the local equipment and typical electrical connection to the transmission or distribution system** * **tests for (i) must precede tests for (ii)** * **smaller step changes must precede larger step changes** |
| --- | --- | --- | --- |
| **7** | **As for 6 but with the PSS in service** | **Same as in part 6** | **Same as in part 6** |
| **8** | **Step change to AVR voltage reference with the generating**  **unit connected to the system.**  **(PSS out of service)**  **System Conditions :**  **(i) system minimum load with no other generation on the same bus OR relatively weak connection to the transmission or distribution system, and**  **(ii) system maximum load and maximum generation on same bus OR relatively strong connection to the transmission or distribution system** | **(a) +5 %**  **(b) -5 %**  **repeat (a) & (b)**  **twice;**  **see note below** | * **nominal stator terminal voltage** * **unity power factor or underexited operation** * **Generating unit output at 100% rated MW** |
| **9** | **As for 8 but with the PSS in service** | **Same as in part 8** | **Same as in part 8** |

* Tests 1,3 and 4 need not be witnessed by the TSO
* For test 3 a positive step is applied of X% from the sub-OEL value. But for test 4 a -Y% step from the sub-UEL value as shown in Figure 3 is required.



**Figure 3.** Application of Step Signal

* For tests 6 and 7 care must be taken not to excite large or prolonged oscillations in MW etc. Therefore, smaller step changes must always precede larger step changes to avoid such oscillations.
* The Figure 4 below shows the step changes referred to in the schedule of tests given above. An example is given of a +5% step to the summing junction and then a -5% step. Removal of the +5% ("-5%") step is deemed to be a -5% step. Unless specified otherwise the "-5%" step method shown in Figure 4 is used.

**Figure 4.** Application of test signal

**Test 5 Active and reactive power tests (PQ curve and Q = const)**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **PQ curve measurements** | 1. **minimum % rated MW**    1. **Q max setpoint**    2. **Q min setpoint** 2. **25 % rated MW**    1. **Q max setpoint**    2. **Q min setpoint** 3. **50 % rated MW**    1. **Q max setpoint**    2. **Q min setpoint** 4. **75% rated MW**     1. **Q max setpoint**    2. **Q min setpoint** 5. **100 % rated MW**    1. **Q max setpoint**    2. **Q min setpoint** | **The min and max Q will be held for 10 minute in each step.**  **Signal from Elering control centre (SCADA if applicable)** |
| **2** | **Q constant** | **(a) 0 Mvar**  **(b) -1/2Qmax rated Mvar**  **(c) +1/2Qmax rated Mvar** | **Q will be held for 10 minute in each step.**  **Signal from Elering control centre (SCADA if applicable)** |
| **3** | **Leading and lagging MVar capability at full MW output.**  **System maximum load and maximum generation. Test conducted with as high an ambient temperature as possible.** | **Generating unit MW and MVar output levels set to 100% of rated values and maintained for one hour both for leading and lagging.** | **System maximum load and generation**  **Signal from Elering control centre (SCADA if applicable)** |

**Test 6 House load test**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **House load test**  **Remaining load – houseload + load connected directly to power plant**  **Test conducted by Elering** | **opening of the link to transmission system** | * **100% of maximum active power of synchronous generating module** * **Test duration 6 hour** * **Resynchronization after 6 hours** |
| **2** | **Islanding of a subsystem consisting of User's generating units plus load with export of power by means of a link to the transmission system.**  **Test conducted by Elering** | **opening of the link** | * **5-10% of generated MW exported by means of the link** * **90-95% of generated MW used by the subsystem's load** * **Each test during 1 hour** * **Resynchronization** |

**Test 7 Over- and underfrequency**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Overspeed capability to stay in the range of 51.0 to 51,5 Hz for a minimum of 30 minutes** | **(a) Digital governor: use software, where practical, to put a step in the speed reference of the turbine governor such that the target speed is 51.5Hz**  **(b) Use a manual control to raise speed from 50Hz so as to stay in the 51,0 to 51,5 Hz range for a minimum of 30 min.**  **(c) Where it is practical, use a function generating unit to inject an analogue signal in the appropriate summing junction, so that the turbine stays in the 51,5 Hz range for a minimum of 30 min.** | **Unsynchronised unit at rated speed and no load** |
| **2** | **Underspeed capability**  **to stay in the range of 48,5 to 47,5Hz for a minimum of 30 minutes** | **To be proposed by the manufacturer** | **Unsynchronised unit at rated speed and no load** |

**Test 8 U = constant test**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Testing U constant functionality** | **(a) XXX kV**  **(b) XXX kV**  **(c) XXX kV**  **Voltage at each step (a)-(c) maintained during 60 minutes** | **Signal from Elering control centre (SCADA if applicable)** |

**Test 9 Load control (secondary control test)**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Variable frequency injection into the AVR summing junction (with PSS out of service)** | **0.01-100 rad/sec**  **See notes below** | * **as determined by Elering** |
| **2** | **Step change to governor/load reference** | **(a) 2.5 % step increase in MW demand signal**  **(b) 2.5 % decrease in MW demand signal**  **(c) equivalent of 0.05Hz subtracted from the governor speed ref.**  **(d) equivalent of 0.1 Hz added to turbine governor speed reference**  **See notes below** | * **equipment output at 50-90% of rated MW** * **others as agreed with Elering** |
| **3** | **Load rejection (real power)**  **Generating unit reactive power output levels:**   1. **maximum leading Mvar** 2. **maximum lagging Mvar** | **(a) 25 % rated MW**  **(b) 50 % rated MW**  **(c) 100 % rated MW**  **See notes below** | * **nominal stator terminal voltage** * **smaller amount must precede larger amount of load rejection** * **Resynchronization** |

| **4** | **Load control (active power setpoint test)**  **Test conducted by Elering if unit connected under AGC** | **(a) minimum % rated MW**  **(b) 50 % rated MW**  **(c) 60 % rated**  **(d) 70 % rated MW**  **(e) 100 % rated MW**  **(f) 90 % rated MW**  **(g) 80 % rated MW**  **(h) 0 MW exported to grid MW**  **Power at each step (a)-(h) maintained during 10 minutes**  **Signal from Elering control centre (SCADA if applicable)** | **Signal from Elering control centre (SCADA if applicable)** |
| --- | --- | --- | --- |

* For test 1, care has to be taken not to excite electromechanical resonances (eg poorly damped MW swings) if the machine is on line.
* For the tests 2 equipment characteristics may require the changes be varied from the nominal values given. Larger changes may be considered in order to more accurately determine equipment performance.
* For test 3, the instantaneous overspeed protection must be set at an agreed level depending on unit capability

**Test 10 Primary control test including LFSM-O and LFSM-U**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Testing power plant behaviour in case of frequency changes in grid.** | **(a) 40 % rated MW**  **(b) 90 % rated MW**  **Frequency steps, droops and deadbands to be determined by Elering** | **Generator need to be synchronized with grid**  **Excitation system is in AVR mode and started.**  **PSS is in service.**  **Generator breaker is closed.**  **Signal from Elering control centre (SCADA if applicable)** |

Example of Primary control test.

Load generator to 40% of rated active power **XX MW**.

Enable frequency control function in the turbine control system

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Frequency control enabled** | **Droop (%)** | **Deadband (mHz)** | **Frequency step (mHz) (all changes from 50 Hz)** | **Expected P change (MW)** | **Duration (after stabilized output), min.** |
| 1 | Yes | 8 | 100 | -80 |  | 5 |
| 2 | Yes | 8 | 100 | 80 |  | 5 |
| 3 | Yes | 8 | 100 | -200 |  | 5 |
| 4 | Yes | 8 | 100 | 200 |  | 15 |
| 5 | Yes | 8 | 0 | -80 |  | 5 |
| 6 | Yes | 8 | 0 | 80 |  | 5 |
| 7 | Yes | 2 | 100 | -80 |  | 5 |
| 8 | Yes | 2 | 100 | 80 |  | 5 |
| 9 | Yes | 2 | 100 | -200 |  | 15 |
| 10 | Yes | 2 | 100 | 200 |  | 5 |
| 11 | Yes | 2 | 0 | -80 |  | 5 |
| 12 | Yes | 2 | 0 | 80 |  | 5 |
| 13 | No | 8 | 0 | -150 |  | 5 |
| 14 | No | 8 | 0 | 150 |  | 5 |
| 15 | No | 8 | 0 | -350 |  | 15 |
| 16 | No | 8 | 0 | 350 |  | 15 |
| 17 | No | 8 | 0 | -500 |  | 5 |
| 18 | No | 8 | 0 | 500 |  | 15 |
| 19 | No | 2 | 0 | -150 |  | 5 |
| 20 | No | 2 | 0 | 350 |  | 5 |
| 21 | No | 2 | 0 | -250 |  | 5 |
| 22 | No | 2 | 0 | 350 |  | 15 |

Load generator to 90% of rated active power **XX MW**.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **Frequency control enabled** | **Droop (%)** | **Deadband (mHz)** | **Frequency step (mHz) (all changes from 50 Hz)** | **Expected P change (MW)** | **Duration (after stabilized output) min.** |
| 1 | Yes | 8 | 100 | -80 |  | 5 |
| 2 | Yes | 8 | 100 | 80 |  | 5 |
| 3 | Yes | 8 | 100 | -200 |  | 5 |
| 4 | Yes | 8 | 100 | 200 |  | 15 |
| 5 | Yes | 8 | 0 | -80 |  | 5 |
| 6 | Yes | 8 | 0 | 80 |  | 5 |
| 7 | Yes | 2 | 100 | -80 |  | 5 |
| 8 | Yes | 2 | 100 | 80 |  | 5 |
| 9 | Yes | 2 | 100 | -200 |  | 15 |
| 10 | Yes | 2 | 100 | 200 |  | 5 |
| 11 | Yes | 2 | 0 | -80 |  | 5 |
| 12 | Yes | 2 | 0 | 80 |  | 5 |
| 13 | No | 8 | 0 | -150 |  | 5 |
| 14 | No | 8 | 0 | 150 |  | 5 |
| 15 | No | 8 | 0 | -350 |  | 15 |
| 16 | No | 8 | 0 | 350 |  | 5 |
| 17 | No | 8 | 0 | -500 |  | 5 |
| 18 | No | 8 | 0 | 500 |  | 15 |
| 19 | No | 2 | 0 | -150 |  | 5 |
| 20 | No | 2 | 0 | 150 |  | 5 |
| 21 | No | 2 | 0 | -350 |  | 5 |
| 22 | No | 2 | 0 | 350 |  | 15 |

**Test 11 Cold start to maximum rated power**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Cold start to maximum rated power**  **Test conducted by Elering** | **Initial start order from Elering control centre (SCADA if applicable)**  **Maximum rated power to be maintained during 1 hour**  **Details to be proposed by the manufacturer** | **At least 24 h shutdown (all primary systems) required before start of the test** |

**Test 12 Testing of a FACTS/HVDC**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Testing of a FACTS device, if any**  **(SVC, TCR, STATCOM, etc.)**  **This test is performed only when requested by Elering** | **agreed separately with Elering** | * **initial conditions determined by Elering** |

**Test 13 Any other test to demonstrate compliance with a declared or registered equipment performance characteristic.**

| **Test No** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Tripping of an adjacent generating unit**  **Test conducted by Elering**  **This test is performed only when requested by Elering** | **tripping of generating unit(s)** | * **initial generating unit loadings as agreed by Elering** |
| **2** | **Any other test to demonstrate compliance with a declared or registered equipment performance characteristic.** | **To be advised** |  |

**Test 14 Fault ride-through (FRT) test**

| **part no.** | **GENERAL DESCRIPTION** | **CHANGES APPLIED** | **TEST CONDITIONS** |
| --- | --- | --- | --- |
| **1** | **Fault ride-through (FRT) test** | **To be proposed and conducted by Elering** | **Up to 250 ms; fault at PCC 2ph-g or 3ph-g; or 1ph-g** |