

# Generator Data

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## 1. History of this Document

Changes in this document:

| Rev. no.: | Date:        | Description of change                                                                                                       |
|-----------|--------------|-----------------------------------------------------------------------------------------------------------------------------|
| 8         | 30 July 2002 | Correction on temp. class for LS 600/660 kW, updating of ABB 660 kW regarding a new design of fanwheel and class H in rotor |

MWPS World

|                                                                                  |                |                     |               |
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## 2. 500 kW Generator

### 2.1 Generator Data, Siemens 500 kW, 50 Hz

|                                         |   |                           |                |
|-----------------------------------------|---|---------------------------|----------------|
| Manufacture                             | : | SIEMENS 1LA1 405-4 ZZ90-Z |                |
| Type                                    | : | Asynchronous generator    |                |
| Building size                           | : | 400                       |                |
| Degree of protection                    | : | IP54                      |                |
| Insulation class                        | : | F                         |                |
| Voltage                                 | : | 3 x 690 V $\pm 10\%$      |                |
| Frequency                               | : | 50 Hz                     |                |
| Number of poles                         | : | 4                         |                |
| Nominal speed                           | : | 1527 RPM                  |                |
| Slip                                    | : | 1.8 %                     |                |
| Winding connection                      | : | star                      |                |
| Power                                   | : | 500 kW                    |                |
| Generator power factor ( $\cos \phi$ ): |   |                           |                |
| 5/4 load                                | : | 0.89                      |                |
| 1/1 load                                | : | 0.88                      |                |
| 3/4 load                                | : | 0.85                      |                |
| 1/2 load                                | : | 0.76                      |                |
| 1/4 load                                | : | 0.55                      |                |
| Generator efficiency (%):               |   |                           |                |
| 5/4 load                                | : | 95.2                      |                |
| 1/1 load                                | : | 95.7                      |                |
| 3/4 load                                | : | 96.0                      |                |
| 1/2 load                                | : | 95.8                      |                |
| 1/4 load                                | : | 94.0                      |                |
| Generator                               |   |                           |                |
| full load current                       | : | 475 A                     |                |
| no load current                         | : | 156 A                     |                |
| Generator reactive power                |   |                           |                |
| no load                                 | : | 186 kVAr                  |                |
| Power factor correction                 | : | 187.5 kVAr                | 250 kVAr       |
| Resulting power factor                  |   |                           |                |
| 5/4 load                                | : | 0.98                      | 0.99           |
| 1/1 load                                | : | 0.99                      | 1.0            |
| 3/4 load                                | : | 0.99                      | 1.0            |
| 1/2 load                                | : | 0.99                      | 1.0 (200 kVAr) |
| 1/4 load                                | : | 1.00                      | 1.0 (200 kVAr) |
| Resulting current                       | : | 424 A                     |                |
| Locked rotor current                    | : | 3750 A                    |                |
| power factor                            | : | 0.24                      |                |
| Rated torque $T_N$                      | : | 3127 Nm                   |                |
| Starting torque (motor)                 |   |                           |                |
| $T_S/T_N$                               | : | 1.55                      |                |

|                                                                                  |                |                     |               |
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Break down torque  $T_{\max}/T_N$

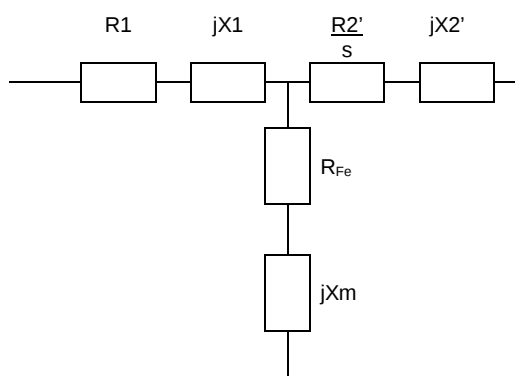
|                           |   |                       |
|---------------------------|---|-----------------------|
| generator                 | : | 3.35                  |
| motor                     | : | 3.85                  |
| Rotor inertia             | : | 7.8 kgm <sup>2</sup>  |
| Noise level (1m distance) | : | 77 dB(A)              |
| Air flow                  | : | 1.3 m <sup>3</sup> /s |
| Weight                    | : | 2.6 t                 |

Temperature rise

|                   |   |      |
|-------------------|---|------|
| PT-100 method     | : | 80 K |
| Resistance method | : | 75 K |

Equivalent diagram

|                       |   |          |                                            |
|-----------------------|---|----------|--------------------------------------------|
| Slip                  | : | $s = 0$  | $s = 1$                                    |
| Stator resistance     | : | $R_1$    | 0.00577 $\Omega$ 0.0057 $\Omega$           |
| Stator reactance      | : | $X_1$    | 0.0782 $\Omega$ 0.0724 $\Omega$            |
| Rotor resistance      | : | $R'_2$   | 0.0161 $\Omega$ 0.020 $\Omega$             |
| Rotor reactance       | : | $X'_2$   | 0.1021 $\Omega$ 0.0313 $\Omega$            |
| Loss resistance       | : | $R_{Fe}$ | 0.037 $\Omega$ 0.037 $\Omega$              |
| Magnetizing reactance | : | $X_m$    | 2.434 $\Omega$ 2.434 $\Omega$              |
| Voltage               | : | $U$      | 690 V/ $\sqrt{3}$ V    690 V/ $\sqrt{3}$ V |



|                                                                                  |                |   |           |           |
|----------------------------------------------------------------------------------|----------------|---|-----------|-----------|
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## 2.2 Generator Data, ABB 500 kW, 50 Hz

|                                         |   |                        |          |            |
|-----------------------------------------|---|------------------------|----------|------------|
| Manufacture                             | : | ABB, M2BA 400XL 4 B3 E |          |            |
| Type                                    | : | Asynchronous generator |          |            |
| Building size                           | : | 400                    |          |            |
| Degree of protection                    | : | IP54                   |          |            |
| Insulation class                        | : | F                      |          |            |
| Voltage                                 | : | 3 x 690 V $\pm 10\%$   |          |            |
| Frequency                               | : | 50 Hz                  |          |            |
| Number of poles                         | : | 4                      |          |            |
| Nominal speed                           | : | 1528 RPM               |          |            |
| Slip                                    | : | 1.9 %                  |          |            |
| Winding connection                      | : | star                   |          |            |
| Power                                   | : | 500 kW                 |          |            |
| Generator power factor ( $\cos \phi$ ): |   |                        |          |            |
| 5/4 load                                | : | 0.91                   |          |            |
| 1/1 load                                | : | 0.92                   |          |            |
| 3/4 load                                | : | 0.91                   |          |            |
| 1/2 load                                | : | 0.87                   |          |            |
| 1/4 load                                | : | 0.71                   |          |            |
| Generator efficiency (%):               |   |                        |          |            |
| 5/4 load                                | : | 95.1                   |          |            |
| 1/1 load                                | : | 95.6                   |          |            |
| 3/4 load                                | : | 95.8                   |          |            |
| 1/2 load                                | : | 95.6                   |          |            |
| 1/4 load                                | : | 93.9                   |          |            |
| Generator                               |   |                        |          |            |
| full load current                       | : | 455 A                  |          |            |
| no load current                         | : | 100 A                  |          |            |
| Generator reactive power                |   |                        |          |            |
| no load                                 | : | 120 kVAr               |          |            |
| Power factor correction                 | : | 125 kVAr               | 250 kVAr |            |
| Resulting power factor                  |   |                        |          |            |
| 5/4 load                                | : | 0.97                   | 1.0      |            |
| 1/1 load                                | : | 0.98                   | 1.0      |            |
| 3/4 load                                | : | 0.99                   | 1.0      | (200 kVAr) |
| 1/2 load                                | : | 1.00                   | 1.0      | (150 kVAr) |
| 1/4 load                                | : | 1.00                   | 0.98     | (150 kVAr) |
| Resulting current                       | : | 425 A                  |          |            |
| Locked rotor current                    | : | 3150 A                 |          |            |
| power factor                            | : | 0.26                   |          |            |
| Rated torque $T_N$                      | : | 3269 Nm                |          |            |
| Starting torque (motor)                 |   |                        |          |            |
| $T_S/T_N$                               | : | 1.8                    |          |            |

|                                                                                  |                |                     |               |
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Break down torque  $T_{\max}/T_N$

generator : 3.0  
motor : -

Rotor inertia :  $17.6 \text{ kgm}^2$

Noise level (1m distance) : 83 dB(A)

Air flow : -

Weight : 3.2 t

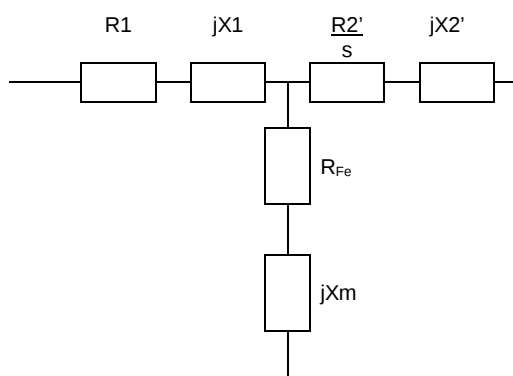
Temperature rise

PT-100 method : 98 K

Resistance method : 89 K

Equivalent diagram

|                       |   |                         |                   |
|-----------------------|---|-------------------------|-------------------|
| Slip                  | : | $s = 0$                 | $s = 1$           |
| Stator resistance     | : | $R_1$ 0.005 $\Omega$    | 0.004 $\Omega$    |
| Stator reactance      | : | $X_1$ 0.073 $\Omega$    | 0.055 $\Omega$    |
| Rotor resistance      | : | $R'_2$ 0.016 $\Omega$   | 0.030 $\Omega$    |
| Rotor reactance       | : | $X'_2$ 0.120 $\Omega$   | 0.091 $\Omega$    |
| Loss resistance       | : | $R_{Fe}$ 0.146 $\Omega$ | 0.146 $\Omega$    |
| Magnetizing reactance | : | $X_m$ 4.0 $\Omega$      | 4.0 $\Omega$      |
| Voltage               | : | $U$ 690/ $\sqrt{3}$ V   | 690/ $\sqrt{3}$ V |



|                                                                                  |                |                     |               |
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## 2.3 Generator Data, Weier 500 kW, 50 Hz

|                                          |   |                        |                 |
|------------------------------------------|---|------------------------|-----------------|
| Manufacture                              | : | Weier, DASG 400 W      |                 |
| Type                                     | : | Asynchronous generator |                 |
| Building size                            | : | 400                    |                 |
| Degree of protection                     | : | IP54                   |                 |
| Insulation class                         | : | F                      |                 |
| Voltage                                  | : | 3 x 690 V $\pm 10\%$   |                 |
| Frequency                                | : | 50 Hz                  |                 |
| Number of poles                          | : | 4                      |                 |
| Nominal speed                            | : | 1546 RPM               |                 |
| Slip                                     | : | 3.1 %                  |                 |
| Winding connection                       | : | star                   |                 |
| Power                                    | : | 500 kW                 |                 |
| Generators power factor ( $\cos \phi$ ): |   |                        |                 |
| 5/4 load                                 | : | 0.90                   |                 |
| 1/1 load                                 | : | 0.89                   |                 |
| 3/4 load                                 | : | 0.86                   |                 |
| 1/2 load                                 | : | 0.78                   |                 |
| 1/4 load                                 | : | 0.58                   |                 |
| Generator efficiency (%):                |   |                        |                 |
| 5/4 load                                 | : | 95.1                   |                 |
| 1/1 load                                 | : | 93.6                   |                 |
| 3/4 load                                 | : | 95.1                   |                 |
| 1/2 load                                 | : | 95.0                   |                 |
| 1/4 load                                 | : | 93.0                   |                 |
| Generator                                |   |                        |                 |
| full load current                        | : | 471 A                  |                 |
| no load current                          | : | 142 A                  |                 |
| Generator reactive power                 |   |                        |                 |
| no load                                  | : | 170 kVAr               |                 |
| Power factor correction                  | : | 175 kVAr               | 250 kVAR        |
| Resulting power factor                   |   |                        |                 |
| 5/4 load                                 | : | 0.98                   | 1.0             |
| 1/1 load                                 | : | 0.99                   | 1.0             |
| 3/4 load                                 | : | 0.99                   | 1.0             |
| 1/2 load                                 | : | 0.99                   | 1.0 (200 kVAR)  |
| 1/4 load                                 | : | 1.00                   | 0.98 (200 kVAR) |
| Resulting current                        | : | 424 A                  |                 |
| Locked rotor current                     |   |                        |                 |
| power factor                             | : | 0.26                   |                 |
| Rated torque $T_N$                       | : | 3290 Nm                |                 |
| Starting torque (motor)                  |   |                        |                 |
| $T_S/T_N$                                | : | 1.7                    |                 |

|                                                                                  |                |                     |               |
|----------------------------------------------------------------------------------|----------------|---------------------|---------------|
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Break down torque  $T_{\max}/T_N$

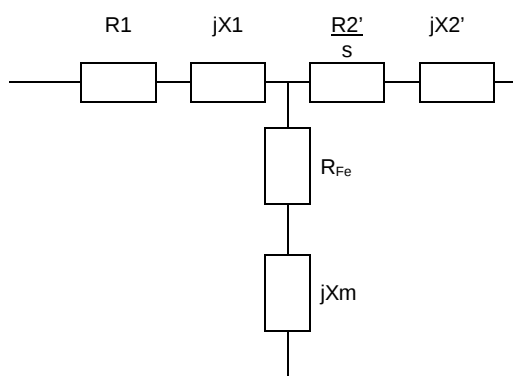
|                           |   |                       |
|---------------------------|---|-----------------------|
| generator                 | : | 3.8                   |
| motor                     | : | 3.5                   |
| Rotor inertia             | : | 24.5 kgm <sup>2</sup> |
| Noise level (1m distance) | : | 85 dB(A)              |
| Air flow                  | : | 1.7 m <sup>3</sup> /s |
| Weight                    | : | 3.1 t                 |

Temperature rise

|                   |   |      |
|-------------------|---|------|
| PT-100 method     | : | 89 K |
| Resistance method | : | 68 K |

Equivalent diagram

|                       |   |                         |
|-----------------------|---|-------------------------|
| Slip                  | : | $s = 0$                 |
| Stator resistance     | : | $R_1$ 0.0040 $\Omega$   |
| Stator reactance      | : | $X_1$ 0.0490 $\Omega$   |
| Rotor resistance      | : | $R'_2$ 0.0234 $\Omega$  |
| Rotor reactance       | : | $X'_2$ 0.0680 $\Omega$  |
| Loss resistance       | : | $R_{Fe}$ 0.034 $\Omega$ |
| Magnetizing reactance | : | $X_m$ 2.580 $\Omega$    |
| Voltage               | : | $U$ 690/ $\sqrt{3}$ V   |



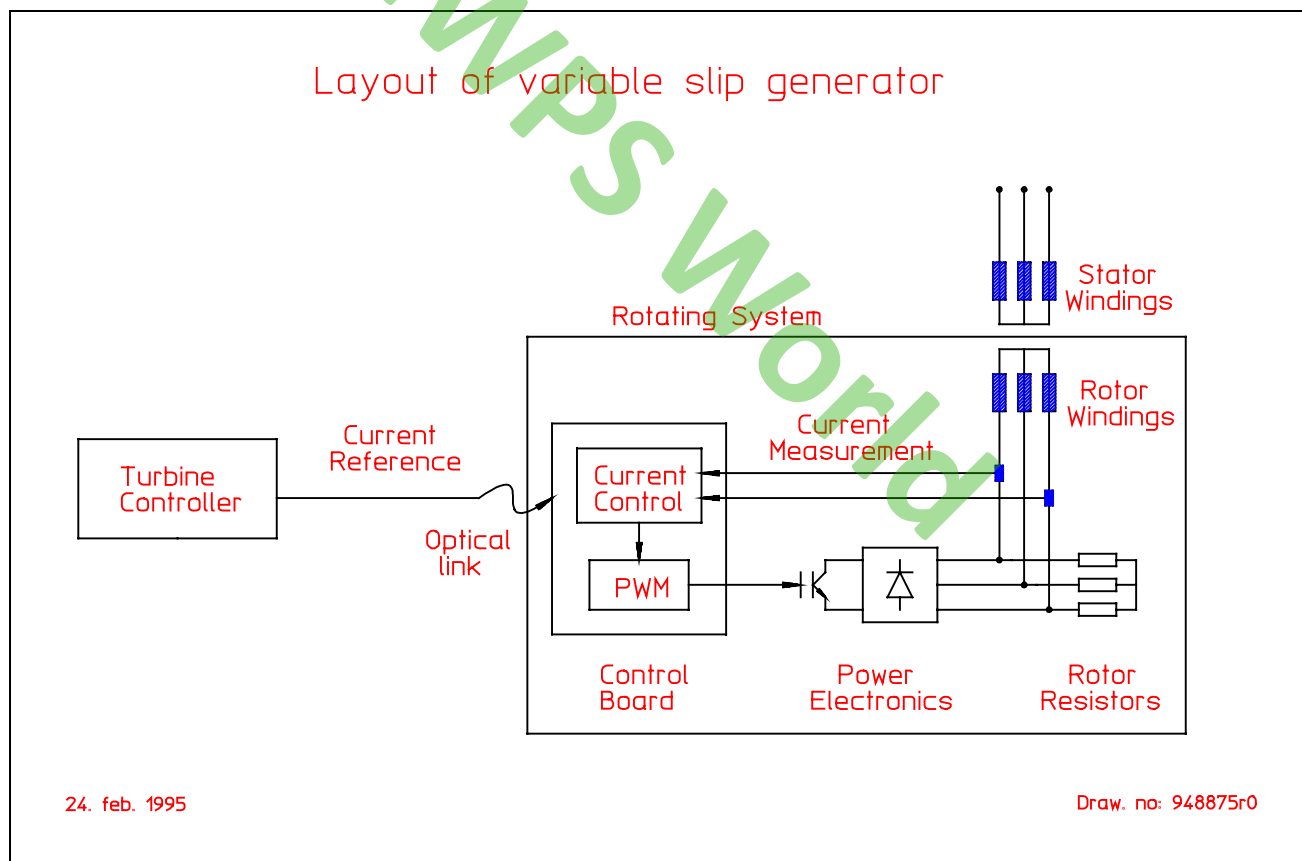
### 3. 600/660 kW Generator

#### 3.1 Description of the 600/660 kW Generator

The 600/660 kW generator for the V39/V42/V44/V47 wind turbine is a variable slip generator, which is a special asynchronous generator with a wound rotor and integrated electronics and rotor resistors, see layout on fig. 1. The electronic and resistor unit is called a **Rotor Current Controller (RCC)** and is located at the non drive end of the generator.

The rotor current reference is sent from the turbine controller to a microprocessor unit inside the RCC. This reference is a setpoint for a fast digital current control which controls the rotor current proportional to the generator power output. The current control is achieved by a pulse width modulation of the resistors. In this way is it possible to adjust the external resistances continuously between zero and maximum.

For a given current reference is it possible for the generator to operate with variable slip and constant power simultaneously. The slip can vary between 1% and 10% at rated power.



**Figure 1** Layout of the variable slip generator.

### 3.2 Generator Data, Weier 600 kW/RCC, 50 Hz

|                                               |   |                                                                                     |            |
|-----------------------------------------------|---|-------------------------------------------------------------------------------------|------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and rotor current control (RCC) |            |
| Manufacturer                                  | : | Weier DASG 400 WL                                                                   |            |
| Building size                                 | : | 400                                                                                 |            |
| Degree of protection                          | : | IP54                                                                                |            |
| Insulation class (stator/rotor)               | : | F/H                                                                                 |            |
| Winding connection (stator/rotor)             | : | star/star                                                                           |            |
| Voltage                                       | : | 3 x 690 V $\pm 10\%$                                                                |            |
| Frequency                                     | : | 50 Hz                                                                               |            |
| Number of poles                               | : | 4                                                                                   |            |
| Rated speed                                   | : | 1575 RPM                                                                            |            |
| Slip regulation interval                      | : | 1-10 %                                                                              |            |
| Rated Slip                                    | : | 5 %                                                                                 |            |
| Rated power output                            | : | 600 kW                                                                              |            |
| Generator power factor ( $\cos \phi$ ):       |   |                                                                                     |            |
| 1/1 load                                      | : | 0.88                                                                                |            |
| 3/4 load                                      | : | 0.84                                                                                |            |
| 1/2 load                                      | : | 0.74                                                                                |            |
| 1/4 load                                      | : | 0.53                                                                                |            |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                     |            |
| 1/1 load                                      | : | 95                                                                                  |            |
| 3/4 load                                      | : | 95                                                                                  |            |
| 1/2 load                                      | : | 95                                                                                  |            |
| 1/4 load                                      | : | 91                                                                                  |            |
| Generator no load loss                        | : | 11 kW                                                                               |            |
| Generator current                             |   |                                                                                     |            |
| full load                                     | : | 571 A                                                                               |            |
| no load                                       | : | 185 A                                                                               |            |
| Generator reactive power                      |   |                                                                                     |            |
| full load                                     | : | 324 kVAr                                                                            |            |
| no load                                       | : | 221 kVAr                                                                            |            |
| Power factor correction                       | : | 225 kVAr                                                                            |            |
| Resulting power factor (grid side)            |   |                                                                                     |            |
| 1/1 load                                      | : | 0.99                                                                                |            |
| 3/4 load                                      | : | 0.99                                                                                |            |
| 1/2 load                                      | : | 0.99                                                                                |            |
| 1/4 load                                      | : | 0.99                                                                                |            |
| Resulting current (grid side)                 | : | 508 A                                                                               |            |
| Locked rotor                                  | : | short-circuited 100 % external                                                      |            |
|                                               |   | rotor                                                                               | resistance |
| Stator current                                | : | 4028 A                                                                              | 3179 A     |
| Power factor                                  | : | 0.08                                                                                | 0.59       |
| Starting torque (TS/TN)                       | : | 0.3                                                                                 | 3.2        |
| Rated torque TN (5 % slip)                    | : | 3829 Nm                                                                             |            |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 3.8                    |
| motor                               | : | 3.5                    |
| Number of rotor systems             | : | 2                      |
| Locked rotor voltage (phase-phase): | : | 543 V                  |
| Rated rotor current per system      | : | 327 A                  |
| External resistance (per phase)     | : | 0.093 $\Omega$         |
| Rotor inertia                       | : | 32 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 95 dB(A)               |
| Air flow from fan                   | : | 7200 m <sup>3</sup> /h |

Weights:

|                     |   |          |
|---------------------|---|----------|
| Generator incl. fan | : | 3,508 kg |
| RCC                 | : | 142 kg   |
| Total               | : | 3,650 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C3 |
| N-end | : | 6234 C3 |

Temperature rise bearings:

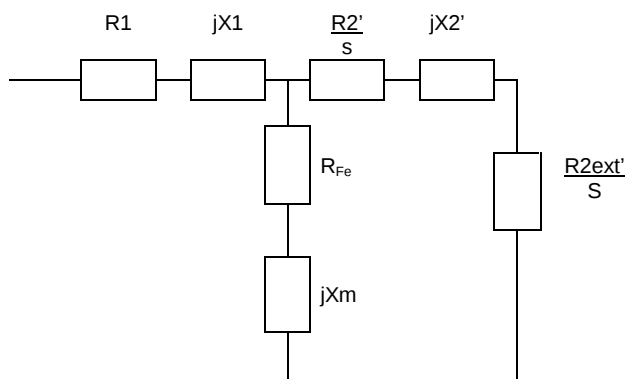
|       |   |      |
|-------|---|------|
| D-end | : | 52 K |
| N-end | : | 32 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 94 K  |
| Rotor  | : | 101 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.0029 $\Omega$   |
| Stator reactance           | : | $X_1$                    | 0.035 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.003 $\Omega$    |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0105 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.066 $\Omega$    |
| Rotor reactance            | : | $X'_2$                   | 0.059 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$                 | 0.0352 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                    | 2.02 $\Omega$     |
| Voltage                    | : | U                        | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                        | 50 Hz             |



|                                                                                  |                |                     |                |
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### 3.3 Generator Data, Weier 600 kW, 50 Hz

|                                               |   |                                                                                             |                 |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|-----------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                 |
| Manufacturer                                  | : | Weier DVSG 400/4L                                                                           |                 |
| Building size                                 | : | 400                                                                                         |                 |
| Degree of protection                          | : | IP54                                                                                        |                 |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                 |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                 |
| Voltage                                       | : | 3 x 690 V $\pm 10\%$                                                                        |                 |
| Frequency                                     | : | 50 Hz                                                                                       |                 |
| Number of poles                               | : | 4                                                                                           |                 |
| Rated speed                                   | : | 1575 RPM                                                                                    |                 |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                 |
| Rated Slip                                    | : | 5 %                                                                                         |                 |
| Rated power output                            | : | 600 kW                                                                                      |                 |
| Generator power factor ( $\cos \phi$ ):       |   |                                                                                             |                 |
| 1/1 load                                      | : | 0.90                                                                                        |                 |
| 3/4 load                                      | : | 0.89                                                                                        |                 |
| 1/2 load                                      | : | 0.82                                                                                        |                 |
| 1/4 load                                      | : | 0.64                                                                                        |                 |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                 |
| 1/1 load                                      | : | 95                                                                                          |                 |
| 3/4 load                                      | : | 95                                                                                          |                 |
| 1/2 load                                      | : | 94                                                                                          |                 |
| 1/4 load                                      | : | 91                                                                                          |                 |
| Generator no load loss                        | : | 14 kW                                                                                       |                 |
| Generator current                             |   |                                                                                             |                 |
| full load                                     | : | 558 A                                                                                       |                 |
| no load                                       | : | 170 A                                                                                       |                 |
| Generator reactive power                      |   |                                                                                             |                 |
| full load                                     | : | 291 kVAr                                                                                    |                 |
| no load                                       | : | 203 kVAr                                                                                    |                 |
| Power factor correction                       | : | 175-225 kVAr, regulated 200-250 kVAr, regulated                                             |                 |
| Resulting power factor (grid side)            |   |                                                                                             |                 |
| 1/1 load                                      | : | 0.99                                                                                        | 1.0             |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0             |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)  |
| 1/4 load                                      | : | 0.99                                                                                        | 0.99 (200 kVAr) |
| Resulting full load current (grid side)       | : | 505 A                                                                                       |                 |
| Locked rotor                                  | : | short-circuited rotor 100 % external resistance                                             |                 |
| Stator current                                | : | 4696 A                                                                                      | 3100 A          |
| Power factor                                  | : | 0.1                                                                                         | 0.7             |
| Starting torque ( $T_S/T_N$ )                 | : | 0.44                                                                                        | 4.2             |
| Rated torque $T_N$ (5 % slip)                 | : | 3829 Nm                                                                                     |                 |

|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                    |   |                        |
|------------------------------------|---|------------------------|
| generator                          | : | 4.8                    |
| motor                              | : | 4.3                    |
| Number of rotor systems            | : | 1                      |
| Locked rotor voltage (phase-phase) | : | 2411 V                 |
| Rated rotor current per system     | : | 146 A                  |
| External resistance (per phase)    | : | 1.0 $\Omega$           |
| Rotor inertia                      | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)          | : | 90 dB(A)               |
| Air flow from fan                  | : | 6500 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,200 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,245 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C4 |
| N-end | : | 6324 C4 |

Temperature rise bearings:

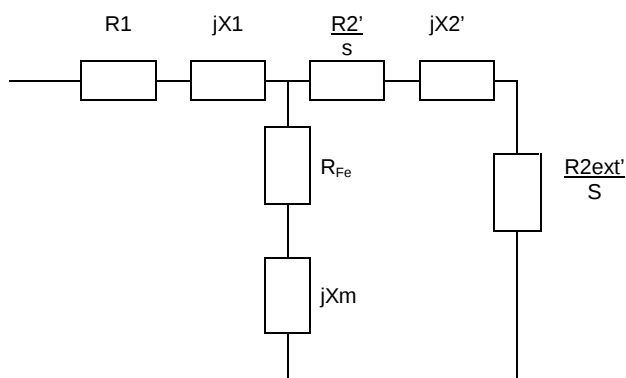
|       |   |      |
|-------|---|------|
| D-end | : | 39 K |
| N-end | : | 46 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 81 K  |
| Rotor  | : | 100 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.0046 $\Omega$   |
| Stator reactance           | : | $X_1$                    | 0.0353 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                   | 0.0043 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0107 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0709 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0425 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.054 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.08 $\Omega$     |
| Voltage                    | : | U                        | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                        | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.4 Generator Data, Weier 660 kW, 50 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Weier DVSG 400/4L                                                                           |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.91                                                                                        |                           |
| 3/4 load                                      | : | 0.89                                                                                        |                           |
| 1/2 load                                      | : | 0.82                                                                                        |                           |
| 1/4 load                                      | : | 0.64                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 610 A                                                                                       |                           |
| no load                                       | : | 170 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 302 kVAr                                                                                    |                           |
| no load                                       | : | 203 kVAr                                                                                    |                           |
| Power factor correction                       | : | 175-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (grid side)            |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 1.0                       |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/4 load                                      | : | 0.99                                                                                        | 1.0 (200 kVAr)            |
| Resulting full load current (grid side)       | : | 556 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 4696 A                                                                                      | 3100 A                    |
| Power factor                                  | : | 0.1                                                                                         | 0.7                       |
| Torque ( $T_S/T_N$ )                          | : | 0.4                                                                                         | 3.8                       |
| Rated torque $T_N$ (5 % slip)                 | : | 4212 Nm                                                                                     |                           |

|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                    |   |                        |
|------------------------------------|---|------------------------|
| generator                          | : | 4.4                    |
| motor                              | : | 3.9                    |
| Number of rotor systems            | : | 1                      |
| Locked rotor voltage (phase-phase) | : | 2411 V                 |
| Rated rotor current per system     | : | 161 A                  |
| External resistance (per phase)    | : | 1.0 $\Omega$           |
| Rotor inertia                      | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)          | : | 90 dB(A)               |
| Air flow from fan                  | : | 6500 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,200 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,245 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C4 |
| N-end | : | 6324 C4 |

Temperature rise bearings:

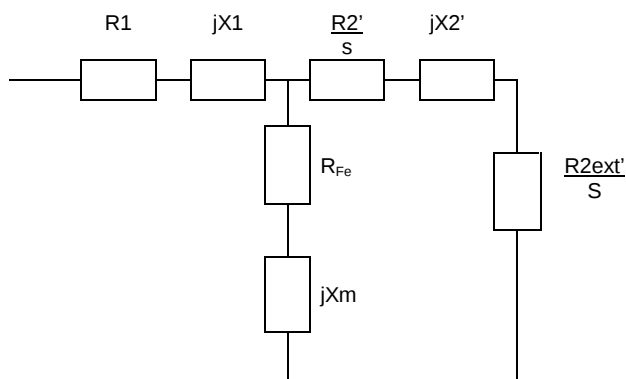
|       |   |      |
|-------|---|------|
| D-end | : | 39 K |
| N-end | : | 46 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 86 K  |
| Rotor  | : | 105 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.0046 $\Omega$   |
| Stator reactance           | : | $X_1$                    | 0.0353 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                   | 0.0043 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0107 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0709 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0425 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.054 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.08 $\Omega$     |
| Voltage                    | : | U                        | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                        | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.5 Generator Data, Weier 600 kW, 60 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Weier DVSG 400/4L                                                                           |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 60 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1890 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 600 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.93                                                                                        |                           |
| 3/4 load                                      | : | 0.91                                                                                        |                           |
| 1/2 load                                      | : | 0.86                                                                                        |                           |
| 1/4 load                                      | : | 0.70                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 93                                                                                          |                           |
| 1/4 load                                      | : | 89                                                                                          |                           |
| Generator no load loss                        | : | 19 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 540 A                                                                                       |                           |
| no load                                       | : | 128 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 240 kVAr                                                                                    |                           |
| no load                                       | : | 153 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 150-250 kVAr, regulated   |
| Resulting power factor (grid side)            |   |                                                                                             |                           |
| 1/1 load                                      | : | 1.0                                                                                         | 1.0                       |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| 1/4 load                                      | : | 0.99                                                                                        | 1.0 (150 kVAr)            |
| Resulting full load current (grid side):      | : | 502 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3735 A                                                                                      | 2858 A                    |
| Power factor                                  | : | 0.08                                                                                        | 0.63                      |
| Torque ( $T_S/T_N$ )                          | : | 0.33                                                                                        | 3.4                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3191 Nm                                                                                     |                           |

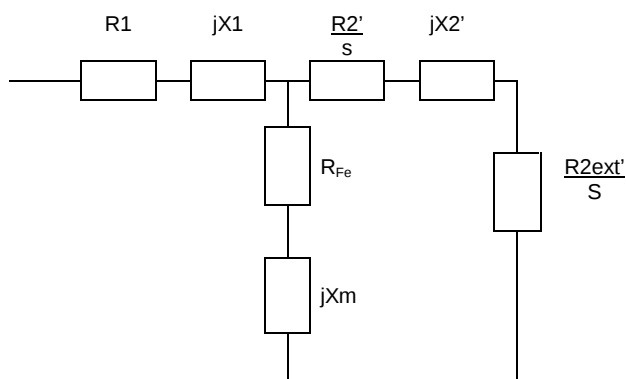
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|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                      |   |                        |
|--------------------------------------|---|------------------------|
| generator                            | : | 3.9                    |
| motor                                | : | 3.5                    |
| Number of rotor systems              | : | 1                      |
| Locked rotor voltage (phase-phase):  | : | 2411 V                 |
| Rated rotor current per system       | : | 146 A                  |
| External resistance (per phase)      | : | 1.0 $\Omega$           |
| Rotor inertia                        | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)            | : | 96 dB(A)               |
| Air flow from fan                    | : | 7800 m <sup>3</sup> /h |
| Weights:                             |   |                        |
| Generator                            | : | 3,200 kg               |
| VRCC                                 | : | 45 kg                  |
| Total                                | : | 3,245 kg               |
| Bearings:                            |   |                        |
| D-end                                | : | 6324 C4                |
| N-end                                | : | 6324 C4                |
| Temperature rise bearings:           |   |                        |
| D-end                                | : | 39 K                   |
| N-end                                | : | 46 K                   |
| Temperature rise windings (hot spot) |   |                        |
| Stator                               | : | 81 K                   |
| Rotor                                | : | 100 K                  |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.0046 $\Omega$   |
| Stator reactance           | : | $X_1$                    | 0.044 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.0043 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0094 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0640 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0552 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.108 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 3.06 $\Omega$     |
| Voltage                    | : | U                        | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                        | 60 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.6 Generator Data, Weier 660 kW, 60 Hz

|                                               |   |                                                                                             |                         |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|-------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                         |
| Manufacturer and type                         | : | Weier DVSG 400/4L                                                                           |                         |
| Building size                                 | : | 400                                                                                         |                         |
| Degree of protection                          | : | IP54                                                                                        |                         |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                         |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                         |
| Voltage                                       | : | 3 x 690 V                                                                                   |                         |
| Frequency                                     | : | 60 Hz                                                                                       |                         |
| Number of poles                               | : | 4                                                                                           |                         |
| Rated speed                                   | : | 1890 RPM                                                                                    |                         |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                         |
| Rated Slip                                    | : | 5 %                                                                                         |                         |
| Rated power output                            | : | 660 kW                                                                                      |                         |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                         |
| 1/1 load                                      | : | 0.93                                                                                        |                         |
| 3/4 load                                      | : | 0.91                                                                                        |                         |
| 1/2 load                                      | : | 0.86                                                                                        |                         |
| 1/4 load                                      | : | 0.70                                                                                        |                         |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                         |
| 1/1 load                                      | : | 95                                                                                          |                         |
| 3/4 load                                      | : | 95                                                                                          |                         |
| 1/2 load                                      | : | 93                                                                                          |                         |
| 1/4 load                                      | : | 89                                                                                          |                         |
| Generator no load loss                        | : | 19 kW                                                                                       |                         |
| Generator current                             |   |                                                                                             |                         |
| full load                                     | : | 594 A                                                                                       |                         |
| no load                                       | : | 128 A                                                                                       |                         |
| Generator reactive power                      |   |                                                                                             |                         |
| full load                                     | : | 258 kVAr                                                                                    |                         |
| no load                                       | : | 153 kVAr                                                                                    |                         |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 150-250 kVAr, regulated |
| Resulting power factor (grid side)            |   |                                                                                             |                         |
| 1/1 load                                      | : | 1.0                                                                                         | 1.0                     |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                     |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)          |
| 1/4 load                                      | : | 0.99                                                                                        | 1.0 (150 kVAr)          |
| Resulting full load current (grid side):      |   | 553 A                                                                                       |                         |
| Locked rotor                                  | : | short-circuited rotor                                                                       |                         |
|                                               |   | 100 % external resistance                                                                   |                         |
| Stator current                                | : | 3735 A                                                                                      | 2858 A                  |
| Power factor                                  | : | 0.08                                                                                        | 0.63                    |
| Torque ( $T_s/T_N$ )                          | : | 0.3                                                                                         | 3.1                     |
| Rated torque $T_N$ (5 % slip)                 | : | 3510 Nm                                                                                     |                         |

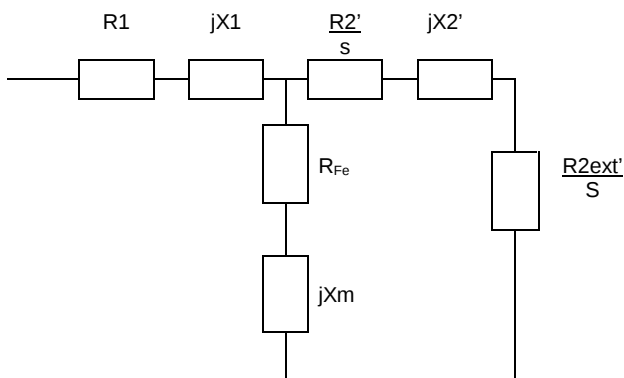
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|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                      |   |                        |
|--------------------------------------|---|------------------------|
| generator                            | : | 3.5                    |
| motor                                | : | 3.2                    |
| Number of rotor systems              | : | 1                      |
| Locked rotor voltage (phase-phase)   | : | 2411 V                 |
| Rated rotor current per system       | : | 161 A                  |
| External resistance (per phase)      | : | 1.0 $\Omega$           |
| Rotor inertia                        | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)            | : | 96 dB(A)               |
| Air flow from fan                    | : | 7800 m <sup>3</sup> /h |
| Weights:                             |   |                        |
| Generator                            | : | 3,200 kg               |
| VRCC                                 | : | 45 kg                  |
| Total                                | : | 3,245 kg               |
| Bearings:                            |   |                        |
| D-end                                | : | 6324 C3                |
| N-end                                | : | 6324 C3                |
| Temperature rise bearings:           |   |                        |
| D-end                                | : | 39 K                   |
| N-end                                | : | 46 K                   |
| Temperature rise windings (hot spot) |   |                        |
| Stator                               | : | 86 K                   |
| Rotor                                | : | 105 K                  |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0046 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.044 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                | 0.0043 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0094 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0640 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.0552 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$              | 0.108 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                 | 3.06 $\Omega$     |
| Voltage                    | : | U                     | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                     | 60 Hz             |



### 3.7 Generator Data, ABB 600 kW, 50 Hz (1st type)

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE004)                                                      |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 600 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ )          | : |                                                                                             |                           |
| 1/1 load                                      | : | 0.88                                                                                        |                           |
| 3/4 load                                      | : | 0.88                                                                                        |                           |
| 1/2 load                                      | : | 0.84                                                                                        |                           |
| 1/4 load                                      | : | 0.69                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): | : |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 11 kW                                                                                       |                           |
| Generator current                             | : |                                                                                             |                           |
| full load                                     | : | 571 A                                                                                       |                           |
| no load                                       | : | 119 A                                                                                       |                           |
| Generator reactive power                      | : |                                                                                             |                           |
| full load                                     | : | 324 kVAr                                                                                    |                           |
| no load                                       | : | 141 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     |                           |
| Resulting power factor (grid side)            | : |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        |                           |
| 3/4 load                                      | : | 1.0                                                                                         |                           |
| 1/2 load                                      | : | 1.0                                                                                         |                           |
| 1/4 load                                      | : | 1.0                                                                                         |                           |
| Resulting full load current (grid side):      | : | 508 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3232 A                                                                                      | 2500 A                    |
| Power factor                                  | : | 0.063                                                                                       | 0.52                      |
| Torque ( $T_S/T_N$ )                          | : | 0.35                                                                                        | 2.2                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3829 Nm                                                                                     |                           |

|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

generator : 2.6  
motor : 2.5

Number of rotor systems : 1  
Locked rotor voltage (phase-phase): 2464 V  
Rated rotor current per system : 150 A  
External resistance (per phase) : 1.0  $\Omega$   
Rotor inertia (incl. VRCC) : 29 kgm<sup>2</sup>  
Noise level (1m distance) : 87 dB(A)  
Air flow from fan : 4300 m<sup>3</sup>/h

Weights:

Generator : 2,980 kg  
VRCC : 45 kg  
Total : 3,025 kg

Bearings:

D-end : 6322 C3  
N-end : 6322 C3

Temperature rise bearings:

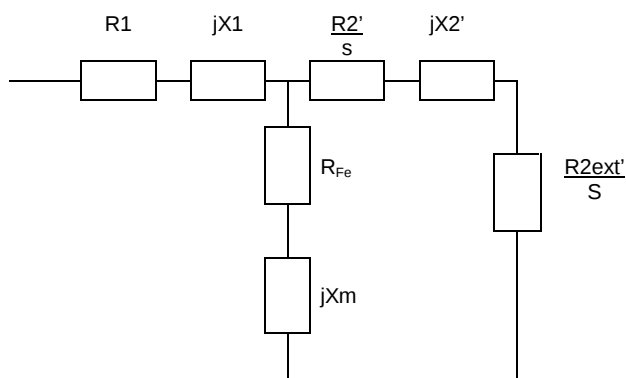
D-end : 40 K  
N-end : 37 K

Temperature rise windings (hot spot)

Stator : 83 K  
Rotor : 97 K

Equivalent diagram (stator side) :

Stator resistance :  $R_1$  0.0047  $\Omega$   
Stator reactance :  $X_1$  0.0734  $\Omega$   
Rotor resistance, internal :  $R'_2$  0.0041  $\Omega$   
Rotor res. ext. (2 % slip) :  $R'_{2 \text{ ext}2}$  0.0100  $\Omega$   
Rotor res. ext. (10% slip) :  $R'_{2 \text{ ext}10}$  0.066  $\Omega$   
Rotor reactance :  $X'_2$  0.113  $\Omega$   
Iron loss :  $R_{Fe}$  0.129  $\Omega$   
Magnetizing reactance :  $X_m$  3.23  $\Omega$   
Voltage :  $U$  690 V/ $\sqrt{3}$   
Frequency :  $f$  50 Hz



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.8 Generator Data, ABB 600 kW, 50 Hz

|                                                     |   |                                                                                             |                           |
|-----------------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                      | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer and type                               | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                           |
| Building size                                       | : | 400                                                                                         |                           |
| Degree of protection                                | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)                     | : | F/F                                                                                         |                           |
| Winding connection (stator/rotor)                   | : | star/star                                                                                   |                           |
| Voltage                                             | : | 3 x 690 V $\pm 10\%$                                                                        |                           |
| Frequency                                           | : | 50 Hz                                                                                       |                           |
| Number of poles                                     | : | 4                                                                                           |                           |
| Rated speed                                         | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                            | : | 1-10 %                                                                                      |                           |
| Rated Slip                                          | : | 5 %                                                                                         |                           |
| Rated power output                                  | : | 600 kW                                                                                      |                           |
| Generator power factor ( $\cos \phi$ )              | : |                                                                                             |                           |
| 1/1 load                                            | : | 0.88                                                                                        |                           |
| 3/4 load                                            | : | 0.88                                                                                        |                           |
| 1/2 load                                            | : | 0.83                                                                                        |                           |
| 1/4 load                                            | : | 0.65                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve):       | : |                                                                                             |                           |
| 1/1 load                                            | : | 95                                                                                          |                           |
| 3/4 load                                            | : | 95                                                                                          |                           |
| 1/2 load                                            | : | 94                                                                                          |                           |
| 1/4 load                                            | : | 91                                                                                          |                           |
| Generator no load loss                              | : | 11 kW                                                                                       |                           |
| Generator current                                   | : |                                                                                             |                           |
| full load                                           | : | 569 A                                                                                       |                           |
| no load                                             | : | 144 A                                                                                       |                           |
| Generator reactive power                            | : |                                                                                             |                           |
| full load                                           | : | 320 kVAr                                                                                    |                           |
| no load                                             | : | 172 kVAr                                                                                    |                           |
| Power factor correction                             | : | 125-225 kVAr, regulated                                                                     | 150-250 kVAr, regulated   |
| Resulting power factor (average value on grid side) | : |                                                                                             |                           |
| 1/1 load                                            | : | 0.99                                                                                        | 0.99                      |
| 3/4 load                                            | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                            | : | 0.99                                                                                        | 1.0 (200 kVAr)            |
| 1/4 load                                            | : | 0.99                                                                                        | 0.99 (200 kVAr)           |
| Resulting full load current (grid side):            | : | 509 A                                                                                       |                           |
| Locked rotor                                        | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                      | : | 3600 A                                                                                      | 2800 A                    |
| Power factor                                        | : | 0.09                                                                                        | 0.63                      |
| Torque ( $T_s/T_N$ )                                | : | 0.26                                                                                        | 2.6                       |
| Rated torque $T_N$ (5 % slip)                       | : | 3829 Nm                                                                                     |                           |

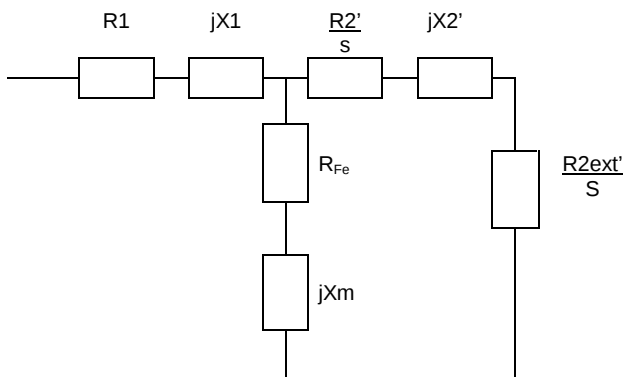
|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                      |   |                        |
|--------------------------------------|---|------------------------|
| generator                            | : | 2.8                    |
| motor                                | : | 2.6                    |
| Number of rotor systems              | : | 1                      |
| Locked rotor voltage (phase-phase):  | : | 2464 V                 |
| Rated rotor current per system       | : | 150 A                  |
| External resistance (per phase)      | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)           | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)            | : | 86 dB(A)               |
| Air flow from fan                    | : | 4300 m <sup>3</sup> /h |
| Weights:                             |   |                        |
| Generator                            | : | 2,980 kg               |
| VRCC                                 | : | 45 kg                  |
| Total                                | : | 3,025 kg               |
| Bearings:                            |   |                        |
| D-end                                | : | 6322 C3                |
| N-end                                | : | 6322 C3                |
| Temperature rise bearings:           |   |                        |
| D-end                                | : | 30 K                   |
| N-end                                | : | 35 K                   |
| Temperature rise windings (hot spot) |   |                        |
| Stator                               | : | 81 K                   |
| Rotor                                | : | 85 K                   |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.068 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0087 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0608 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.0897 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$              | 0.0709 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                 | 2.81 $\Omega$     |
| Voltage                    | : | U                     | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                     | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.9 Generator Data, ABB 660 kW, 50 Hz Serial no. <3409481

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                           |
| Fan type no.                                  | : | CA40T/H431513                                                                               |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.88                                                                                        |                           |
| 3/4 load                                      | : | 0.88                                                                                        |                           |
| 1/2 load                                      | : | 0.83                                                                                        |                           |
| 1/4 load                                      | : | 0.65                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 11 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 625 A                                                                                       |                           |
| no load                                       | : | 144 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 349 kVAr                                                                                    |                           |
| no load                                       | : | 172 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (grid side)            |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.98                                                                                        | 0.99                      |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 0.99                                                                                        | 1.0                       |
| 1/4 load                                      | : | 0.99                                                                                        | 1.0 (200 kVAr)            |
| Resulting full load current (grid side):      |   | 563A                                                                                        |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3600 A                                                                                      | 2800 A                    |
| Power factor                                  | : | 0.09                                                                                        | 0.63                      |
| Torque ( $T_S/T_N$ )                          | : | 0.24                                                                                        | 2.4                       |
| Rated torque $T_N$ (5 % slip)                 | : | 4212 Nm                                                                                     |                           |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.5                    |
| motor                               | : | 2.4                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2464 V                 |
| Rated rotor current per system      | : | 166 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 86 dB(A)               |
| Air flow from fan                   | : | 4300 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 2,980 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,025 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6322 C3 |
| N-end | : | 6322 C3 |

Temperature rise bearings:

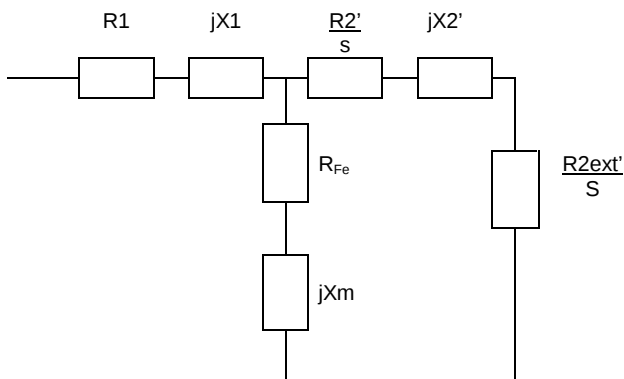
|       |   |      |
|-------|---|------|
| D-end | : | 30 K |
| N-end | : | 35 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 93 K  |
| Rotor  | : | 101 K |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.068 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0087 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0608 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.0897 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$              | 0.0709 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                 | 2.81 $\Omega$     |
| Voltage                    | : | U                     | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                     | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.10 Generator Data, ABB 660 kW, 50 Hz 3409481 ≤ Serial no. < 3445843

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                           |
| Fan type no.                                  | : | CA40T/H431513                                                                               |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.88                                                                                        |                           |
| 3/4 load                                      | : | 0.88                                                                                        |                           |
| 1/2 load                                      | : | 0.83                                                                                        |                           |
| 1/4 load                                      | : | 0.65                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 11 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 625 A                                                                                       |                           |
| no load                                       | : | 144 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 349 kVAr                                                                                    |                           |
| no load                                       | : | 172 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (grid side)            |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.98                                                                                        | 0.99                      |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 0.99                                                                                        | 1.0                       |
| 1/4 load                                      | : | 0.99                                                                                        | 1.0 (200 kVAr)            |
| Resulting full load current (grid side):      |   | 563A                                                                                        |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3600 A                                                                                      | 2800 A                    |
| Power factor                                  | : | 0.09                                                                                        | 0.63                      |
| Torque ( $T_S/T_N$ )                          | : | 0.24                                                                                        | 2.4                       |
| Rated torque $T_N$ (5 % slip)                 | : | 4212 Nm                                                                                     |                           |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>VESTAS</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.5                    |
| motor                               | : | 2.4                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2464 V                 |
| Rated rotor current per system      | : | 166 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 86 dB(A)               |
| Air flow from fan                   | : | 4300 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 2,980 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,025 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6322 C3 |
| N-end | : | 6322 C3 |

Temperature rise bearings:

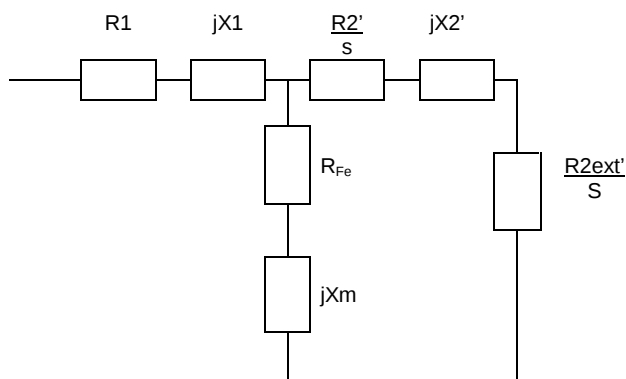
|       |   |      |
|-------|---|------|
| D-end | : | 30 K |
| N-end | : | 35 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 93 K  |
| Rotor  | : | 101 K |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.068 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0087 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0608 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.0897 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$              | 0.0709 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                 | 2.81 $\Omega$     |
| Voltage                    | : | U                     | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                     | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
| Date: 30 July 2002                                                               | Class: 2       | Item no.: 941872.R8 | Page: 28 of 63 |

### 3.11 Generator Data, ABB 660 kW, 50 Hz Serial no. ≥ 3445843

|                                               |   |                                                                                             |                   |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|-------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                   |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                   |
| Fan type no.                                  | : | H323706/2                                                                                   |                   |
| Building size                                 | : | 400                                                                                         |                   |
| Degree of protection                          | : | IP54                                                                                        |                   |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                   |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                   |
| Voltage                                       | : | 3 x 690 V                                                                                   |                   |
| Frequency                                     | : | 50 Hz                                                                                       |                   |
| Number of poles                               | : | 4                                                                                           |                   |
| Rated speed                                   | : | 1575 RPM                                                                                    |                   |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                   |
| Rated Slip                                    | : | 5 %                                                                                         |                   |
| Rated power output                            | : | 660 kW                                                                                      |                   |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                   |
| 1/1 load                                      | : | 0.88                                                                                        |                   |
| 3/4 load                                      | : | 0.88                                                                                        |                   |
| 1/2 load                                      | : | 0.83                                                                                        |                   |
| 1/4 load                                      | : | 0.65                                                                                        |                   |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                   |
| 1/1 load                                      | : | 95                                                                                          |                   |
| 3/4 load                                      | : | 95                                                                                          |                   |
| 1/2 load                                      | : | 94                                                                                          |                   |
| 1/4 load                                      | : | 91                                                                                          |                   |
| Generator no load loss                        | : | 11 kW                                                                                       |                   |
| Generator current                             |   |                                                                                             |                   |
| full load                                     | : | 625 A                                                                                       |                   |
| no load                                       | : | 144 A                                                                                       |                   |
| Generator reactive power                      |   |                                                                                             |                   |
| full load                                     | : | 349 kVAr                                                                                    |                   |
| no load                                       | : | 172 kVAr                                                                                    |                   |
| Power factor correction                       | : | 125-225 kVAr, regulated    200-250 kVAr, regulated                                          |                   |
| Resulting power factor (grid side)            |   |                                                                                             |                   |
| 1/1 load                                      | : | 0.98                                                                                        | 0.99              |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0               |
| 1/2 load                                      | : | 0.99                                                                                        | 1.0               |
| 1/4 load                                      | : | 0.99                                                                                        | 1.0    (200 kVAr) |
| Resulting full load current (grid side):      |   | 563A                                                                                        |                   |
| Locked rotor                                  | : | short-circuited    100 % external resistance                                                |                   |
| Stator current                                | : | 3600 A                                                                                      | 2800 A            |
| Power factor                                  | : | 0.09                                                                                        | 0.63              |
| Torque ( $T_S/T_N$ )                          | : | 0.24                                                                                        | 2.4               |
| Rated torque $T_N$ (5 % slip)                 | : | 4212 Nm                                                                                     |                   |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.5                    |
| motor                               | : | 2.4                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2464 V                 |
| Rated rotor current per system      | : | 166 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 86 dB(A)               |
| Air flow from fan                   | : | 4300 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 2,980 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,025 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6322 C3 |
| N-end | : | 6322 C3 |

Temperature rise bearings:

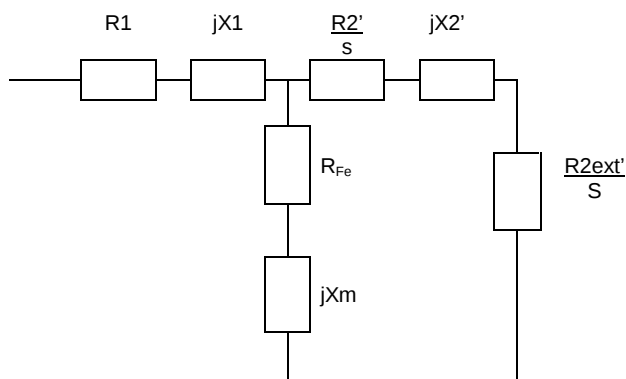
|       |   |      |
|-------|---|------|
| D-end | : | 25 K |
| N-end | : | 28 K |

Temperature rise windings (hot spot)

|        |   |      |
|--------|---|------|
| Stator | : | 89 K |
| Rotor  | : | 99 K |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.068 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0087 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0608 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.0897 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$              | 0.0709 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                 | 2.81 $\Omega$     |
| Voltage                    | : | U                     | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                     | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.12 Generator Data, ABB 600 kW, 60 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 60 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1890 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 600 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.89                                                                                        |                           |
| 3/4 load                                      | : | 0.89                                                                                        |                           |
| 1/2 load                                      | : | 0.87                                                                                        |                           |
| 1/4 load                                      | : | 0.74                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 90                                                                                          |                           |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 564 A                                                                                       |                           |
| no load                                       | : | 110 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 307 kVAr                                                                                    |                           |
| no load                                       | : | 131 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 150-250 kVAr, regulated   |
| Resulting power factor (grid side)            |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 1.0                       |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (150 kVAr)            |
| Resulting full load current (grid side):      |   | 507                                                                                         |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 2800 A                                                                                      | 2300 A                    |
| Power factor                                  | : | 0.078                                                                                       | 0.54                      |
| Torque ( $T_S/T_N$ )                          | : | 0.23                                                                                        | 2.64                      |
| Rated torque $T_N$ (5 % slip)                 | : | 3191 Nm                                                                                     |                           |

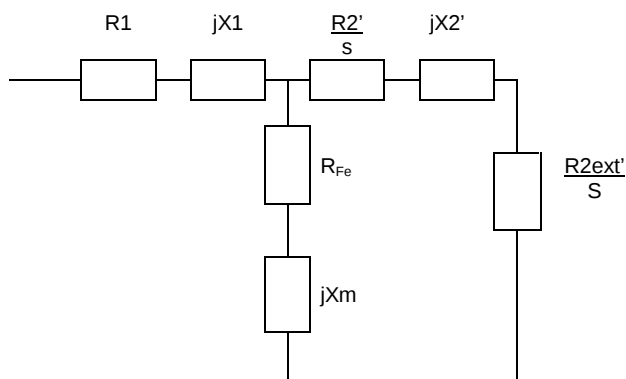
|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                      |   |                        |
|--------------------------------------|---|------------------------|
| generator                            | : | 2.3                    |
| motor                                | : | 2.1                    |
| Number of rotor systems              | : | 1                      |
| Locked rotor voltage (phase-phase):  | : | 2464 V                 |
| Rated rotor current per system       | : | 150 A                  |
| External resistance (per phase)      | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)           | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)            | : | 89 dB(A)               |
| Air flow from fan                    | : | 5000 m <sup>3</sup> /h |
| Weights:                             |   |                        |
| Generator                            | : | 2,980 kg               |
| VRCC                                 | : | 45 kg                  |
| Total                                | : | 3,025 kg               |
| Bearings:                            |   |                        |
| D-end                                | : | 6322 C3                |
| N-end                                | : | 6322 C3                |
| Temperature rise bearings:           |   |                        |
| D-end                                | : | 30 K                   |
| N-end                                | : | 35 K                   |
| Temperature rise windings (hot spot) |   |                        |
| Stator                               | : | 79 K                   |
| Rotor                                | : | 85 K                   |

Equivalent diagram (stator side):

|                            |   |                        |                   |
|----------------------------|---|------------------------|-------------------|
| Stator resistance          | : | $R_1$                  | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                  | 0.0816 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                 | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext}2}$  | 0.0086 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext}10}$ | 0.0596 $\Omega$   |
| Rotor reactance            | : | $X'_2$                 | 0.108 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$               | 0.111 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                  | 3.72 $\Omega$     |
| Voltage                    | : | U                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                      | 60 Hz             |



|                                                                                  |          |                     |                |  |
|----------------------------------------------------------------------------------|----------|---------------------|----------------|--|
|  |          | Generator Data      |                |  |
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### 3.13 Generator Data, ABB 660 kW, 60 Hz Serial no. <3409481

|                                               |   |                                                                                             |                           |  |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|--|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |  |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                           |  |
| Fan type no.                                  | : | CA40T/H431513                                                                               |                           |  |
| Building size                                 | : | 400                                                                                         |                           |  |
| Degree of protection                          | : | IP54                                                                                        |                           |  |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                           |  |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |  |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |  |
| Frequency                                     | : | 60 Hz                                                                                       |                           |  |
| Number of poles                               | : | 4                                                                                           |                           |  |
| Rated speed                                   | : | 1890 RPM                                                                                    |                           |  |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |  |
| Rated Slip                                    | : | 5 %                                                                                         |                           |  |
| Rated power output                            | : | 660 kW                                                                                      |                           |  |
| Generator power factor (cos φ):               |   |                                                                                             |                           |  |
| 1/1 load                                      | : | 0.89                                                                                        |                           |  |
| 3/4 load                                      | : | 0.89                                                                                        |                           |  |
| 1/2 load                                      | : | 0.87                                                                                        |                           |  |
| 1/4 load                                      | : | 0.74                                                                                        |                           |  |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |  |
| 1/1 load                                      | : | 95                                                                                          |                           |  |
| 3/4 load                                      | : | 95                                                                                          |                           |  |
| 1/2 load                                      | : | 94                                                                                          |                           |  |
| 1/4 load                                      | : | 90                                                                                          |                           |  |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |  |
| Generator current                             |   |                                                                                             |                           |  |
| full load                                     | : | 622 A                                                                                       |                           |  |
| no load                                       | : | 110 A                                                                                       |                           |  |
| Generator reactive power                      |   |                                                                                             |                           |  |
| full load                                     | : | 342 kVAr                                                                                    |                           |  |
| no load                                       | : | 131 kVAr                                                                                    |                           |  |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 150-250 kVAr, regulated   |  |
| Resulting power factor (grid side)            |   |                                                                                             |                           |  |
| 1/1 load                                      | : | 0.99                                                                                        | 0.99                      |  |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |  |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |  |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (150 kVAr)            |  |
| Resulting full load current (grid side):      | : | 560A                                                                                        |                           |  |
| Locked rotor                                  | : | short-circuited                                                                             |                           |  |
|                                               |   | rotor                                                                                       | 100 % external resistance |  |
| Stator current                                | : | 2800 A                                                                                      | 2300 A                    |  |
| Power factor                                  | : | 0.078                                                                                       | 0.54                      |  |
| Torque (T <sub>S</sub> /T <sub>N</sub> )      | : | 0.21                                                                                        | 2.4                       |  |
| Rated torque T <sub>N</sub> (5 % slip)        | : | 3510 Nm                                                                                     |                           |  |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                    |   |                        |
|------------------------------------|---|------------------------|
| generator                          | : | 2.1                    |
| motor                              | : | 1.9                    |
| Number of rotor systems            | : | 1                      |
| Locked rotor voltage (phase-phase) | : | 2464 V                 |
| Rated rotor current per system     | : | 166 A                  |
| External resistance (per phase)    | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)         | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)          | : | 89 dB(A)               |
| Air flow from fan                  | : | 5000 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 2,980 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,025 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6322 C3 |
| N-end | : | 6322 C3 |

Temperature rise bearings:

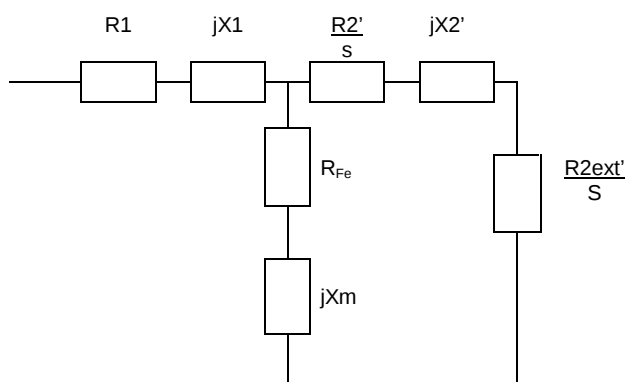
|       |   |      |
|-------|---|------|
| D-end | : | 30 K |
| N-end | : | 35 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 93 K  |
| Rotor  | : | 102 K |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.0816 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0086 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0596 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.108 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$              | 0.111 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                 | 3.72 $\Omega$     |
| Voltage                    | : | $U$                   | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                   | 60 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.14 Generator Data, ABB 660 kW, 60 Hz, 3409481 ≤ Serial no. < 3445843

|                                               |   |                                                                                             |                |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|----------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                |
| Fan type no.                                  | : | CA40T/H431513                                                                               |                |
| Building size                                 | : | 400                                                                                         |                |
| Degree of protection                          | : | IP54                                                                                        |                |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                |
| Voltage                                       | : | 3 x 690 V                                                                                   |                |
| Frequency                                     | : | 60 Hz                                                                                       |                |
| Number of poles                               | : | 4                                                                                           |                |
| Rated speed                                   | : | 1890 RPM                                                                                    |                |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                |
| Rated Slip                                    | : | 5 %                                                                                         |                |
| Rated power output                            | : | 660 kW                                                                                      |                |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                |
| 1/1 load                                      | : | 0.89                                                                                        |                |
| 3/4 load                                      | : | 0.89                                                                                        |                |
| 1/2 load                                      | : | 0.87                                                                                        |                |
| 1/4 load                                      | : | 0.74                                                                                        |                |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                |
| 1/1 load                                      | : | 95                                                                                          |                |
| 3/4 load                                      | : | 95                                                                                          |                |
| 1/2 load                                      | : | 94                                                                                          |                |
| 1/4 load                                      | : | 90                                                                                          |                |
| Generator no load loss                        | : | 14 kW                                                                                       |                |
| Generator current                             |   |                                                                                             |                |
| full load                                     | : | 622 A                                                                                       |                |
| no load                                       | : | 110 A                                                                                       |                |
| Generator reactive power                      |   |                                                                                             |                |
| full load                                     | : | 342 kVAr                                                                                    |                |
| no load                                       | : | 131 kVAr                                                                                    |                |
| Power factor correction                       | : | 125-225 kVAr, regulated 150-250 kVAr, regulated                                             |                |
| Resulting power factor (grid side)            |   |                                                                                             |                |
| 1/1 load                                      | : | 0.99                                                                                        | 0.99           |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0            |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr) |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (150 kVAr) |
| Resulting full load current (grid side):      |   | 560A                                                                                        |                |
| Locked rotor                                  | : | short-circuited 100 % external resistance                                                   |                |
| Stator current                                | : | 2800 A                                                                                      | 2300 A         |
| Power factor                                  | : | 0.078                                                                                       | 0.54           |
| Torque ( $T_S/T_N$ )                          | : | 0.21                                                                                        | 2.4            |
| Rated torque $T_N$ (5 % slip)                 | : | 3510 Nm                                                                                     |                |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>VESTAS</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.1                    |
| motor                               | : | 1.9                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2464 V                 |
| Rated rotor current per system      | : | 166 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 89 dB(A)               |
| Air flow from fan                   | : | 5000 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 2,980 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,025 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6322 C3 |
| N-end | : | 6322 C3 |

Temperature rise bearings:

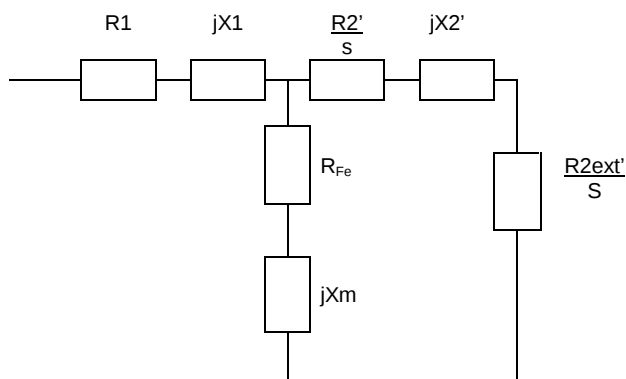
|       |   |      |
|-------|---|------|
| D-end | : | 30 K |
| N-end | : | 35 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 93 K  |
| Rotor  | : | 102 K |

Equivalent diagram (stator side):

|                            |   |                       |                   |
|----------------------------|---|-----------------------|-------------------|
| Stator resistance          | : | $R_1$                 | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                 | 0.0816 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2\text{ ext}2}$  | 0.0086 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2\text{ ext}10}$ | 0.0596 $\Omega$   |
| Rotor reactance            | : | $X'_2$                | 0.108 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$              | 0.111 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                 | 3.72 $\Omega$     |
| Voltage                    | : | U                     | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                     | 60 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.15 Generator Data, ABB 660 kW, 60 Hz Serial no. $\geq$ 3445843

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer and type                         | : | ABB M2CG 400 XL 4 B3 (code: -RXAVE007)                                                      |                           |
| Fan type no.                                  | : | H323706/2                                                                                   |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/H                                                                                         |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 60 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1890 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor ( $\cos \phi$ ):       |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.89                                                                                        |                           |
| 3/4 load                                      | : | 0.89                                                                                        |                           |
| 1/2 load                                      | : | 0.87                                                                                        |                           |
| 1/4 load                                      | : | 0.74                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 90                                                                                          |                           |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 622 A                                                                                       |                           |
| no load                                       | : | 110 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 342 kVAr                                                                                    |                           |
| no load                                       | : | 131 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated 150-250 kVAr, regulated                                             |                           |
| Resulting power factor (grid side)            |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 0.99                      |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (150 kVAr)            |
| Resulting full load current (grid side):      |   | 560A                                                                                        |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 2800 A                                                                                      | 2300 A                    |
| Power factor                                  | : | 0.078                                                                                       | 0.54                      |
| Torque ( $T_S/T_N$ )                          | : | 0.21                                                                                        | 2.4                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3510 Nm                                                                                     |                           |

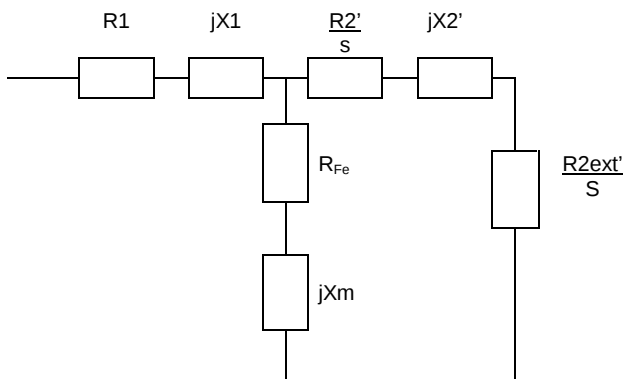
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|--------------------|----------------|---------------------|----------------|
| <b>VESTAS</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                      |   |                        |
|--------------------------------------|---|------------------------|
| generator                            | : | 2.1                    |
| motor                                | : | 1.9                    |
| Number of rotor systems              | : | 1                      |
| Locked rotor voltage (phase-phase):  | : | 2464 V                 |
| Rated rotor current per system       | : | 166 A                  |
| External resistance (per phase)      | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)           | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)            | : | 89 dB(A)               |
| Air flow from fan                    | : | 5000 m <sup>3</sup> /h |
| Weights:                             |   |                        |
| Generator                            | : | 2,980 kg               |
| VRCC                                 | : | 45 kg                  |
| Total                                | : | 3,025 kg               |
| Bearings:                            |   |                        |
| D-end                                | : | 6322 C3                |
| N-end                                | : | 6322 C3                |
| Temperature rise bearings:           |   |                        |
| D-end                                | : | 30 K                   |
| N-end                                | : | 35 K                   |
| Temperature rise windings (hot spot) |   |                        |
| Stator                               | : | 92 K                   |
| Rotor                                | : | 102 K                  |

Equivalent diagram (stator side):

|                            |   |                        |                   |
|----------------------------|---|------------------------|-------------------|
| Stator resistance          | : | $R_1$                  | 0.0048 $\Omega$   |
| Stator reactance           | : | $X_1$                  | 0.0816 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                 | 0.0040 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext}2}$  | 0.0086 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext}10}$ | 0.0596 $\Omega$   |
| Rotor reactance            | : | $X'_2$                 | 0.108 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$               | 0.111 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                  | 3.72 $\Omega$     |
| Voltage                    | : | U                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | f                      | 60 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.16 Generator Data, Leroy Somer 600 kW 50 Hz (1st type)

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Leroy Somer FLSB 400 LKB                                                                    |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | H/H (Nameplate can by mistake state F/H)                                                    |                           |
| Winding connection (stator/rotor)             | : | star/star                                                                                   |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 600 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.88                                                                                        |                           |
| 3/4 load                                      | : | 0.86                                                                                        |                           |
| 1/2 load                                      | : | 0.79                                                                                        |                           |
| 1/4 load                                      | : | 0.59                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 571 A                                                                                       |                           |
| no load                                       | : | 163 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 324 kVAr                                                                                    |                           |
| no load                                       | : | 194 kVAr                                                                                    |                           |
| Power factor correction                       | : | 175-225 kVAr, regulated                                                                     |                           |
| Resulting power factor (average on grid side) |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        |                           |
| 3/4 load                                      | : | 1.0                                                                                         |                           |
| 1/2 load                                      | : | 1.0                                                                                         |                           |
| 1/4 load                                      | : | 1.0                                                                                         |                           |
| Resulting full load current (grid side):      |   | 508 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3976 A                                                                                      | 2100 A                    |
| Power factor                                  | : | 0.11                                                                                        | 0.5                       |
| Torque ( $T_S/T_N$ )                          | : | 0.42                                                                                        | 1.9                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3829 Nm                                                                                     |                           |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestels</b>     | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 3.1                    |
| motor                               | : | 3.0                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2415 V                 |
| Rated rotor current per system      | : | 150 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 87 dB(A)               |
| Air flow from fan                   | : | 6500 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,500 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,545 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C3 |
| N-end | : | 6324 C3 |

Axial run-out of inner ring :  $\leq 9\mu\text{m}$

Radial run-out of inner ring :  $\leq 13\mu\text{m}$

Temperature rise bearings:

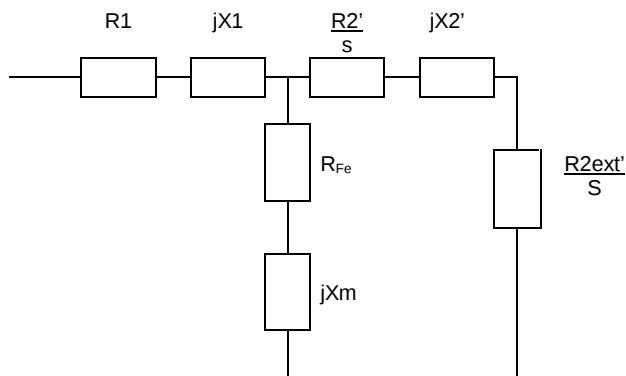
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|-------|---|------|
| D-end | : | 25 K |
| N-end | : | 44 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 92 K  |
| Rotor  | : | 102 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00357 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.055 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.0055 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0095 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.070 $\Omega$    |
| Rotor reactance            | : | $X'_2$                   | 0.0662 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.085 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.39 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.17 Generator Data, Leroy Somer 600 kW, 50 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Leroy Somer FLSB 400 LKC                                                                    |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | H/H (Nameplate can by mistake state F/H)                                                    |                           |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 600 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.89                                                                                        |                           |
| 3/4 load                                      | : | 0.87                                                                                        |                           |
| 1/2 load                                      | : | 0.80                                                                                        |                           |
| 1/4 load                                      | : | 0.59                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 567 A                                                                                       |                           |
| no load                                       | : | 182 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 316 kVAr                                                                                    |                           |
| no load                                       | : | 217 kVAr                                                                                    |                           |
| Power factor correction                       | : | 175-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (average on grid side) |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 1.0                       |
| 3/4 load                                      | : | 0.99                                                                                        | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| Resulting full load current (grid side):      |   | 508 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 4400 A                                                                                      | 3200 A                    |
| Power factor                                  | : | 0.17                                                                                        | 0.7                       |
| Torque ( $T_S/T_N$ )                          | : | 0.57                                                                                        | 2.8                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3829 Nm                                                                                     |                           |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestels</b>     | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 3.2                    |
| motor                               | : | 3.4                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2460 V                 |
| Rated rotor current per system      | : | 148 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 87 dB(A)               |
| Air flow from fan                   | : | 6500 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C3 |
| N-end | : | 6324 C3 |

Axial run-out of inner ring :  $\leq 9\mu\text{m}$

Radial run-out of inner ring :  $\leq 13\mu\text{m}$

Temperature rise bearings:

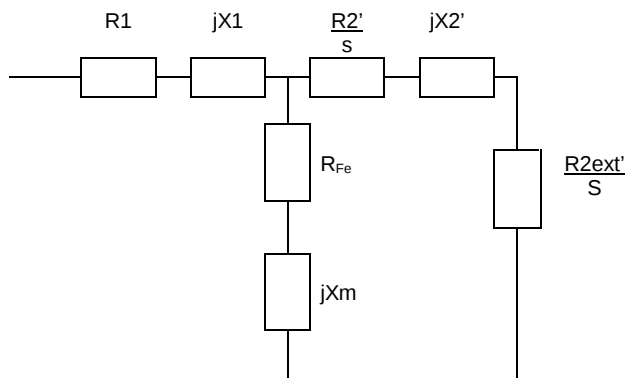
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|-------|---|------|
| D-end | : | 40 K |
| N-end | : | 50 K |

Temperature rise windings (hot spot)

|        |   |      |
|--------|---|------|
| Stator | : | 80 K |
| Rotor  | : | 90 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00347 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.0583 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                   | 0.0049 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.00817 $\Omega$  |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0605 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0648 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.0956 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                    | 2.13 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.18 Generator Data, Leroy Somer 660 kW, 50 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Leroy Somer FLSB 400 LKC                                                                    |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | H/H (Nameplate can by mistake state F/H)                                                    |                           |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.89                                                                                        |                           |
| 3/4 load                                      | : | 0.87                                                                                        |                           |
| 1/2 load                                      | : | 0.80                                                                                        |                           |
| 1/4 load                                      | : | 0.59                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 14 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 619 A                                                                                       |                           |
| no load                                       | : | 182 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 334 kVAr                                                                                    |                           |
| no load                                       | : | 217 kVAr                                                                                    |                           |
| Power factor correction                       | : | 175-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (average on grid side) |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 0.99                      |
| 3/4 load                                      | : | 0.99                                                                                        | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/4 load                                      | : | 1.0                                                                                         | 0.99                      |
| Resulting full load current (grid side):      |   | 560 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 4400 A                                                                                      | 3200                      |
| Power factor                                  | : | 0.17                                                                                        | 0.7                       |
| Torque ( $T_S/T_N$ )                          | : | 0.52                                                                                        | 2.5                       |
| Rated torque $T_N$ (5 % slip)                 | : | 4212 Nm                                                                                     |                           |

|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.9                    |
| motor                               | : | 3.1                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2460 V                 |
| Rated rotor current per system      | : | 163 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 87 dB(A)               |
| Air flow from fan                   | : | 6500 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C3 |
| N-end | : | 6324 C3 |

Axial run-out of inner ring :  $\leq 9\mu\text{m}$

Radial run-out of inner ring :  $\leq 13\mu\text{m}$

Temperature rise bearings:

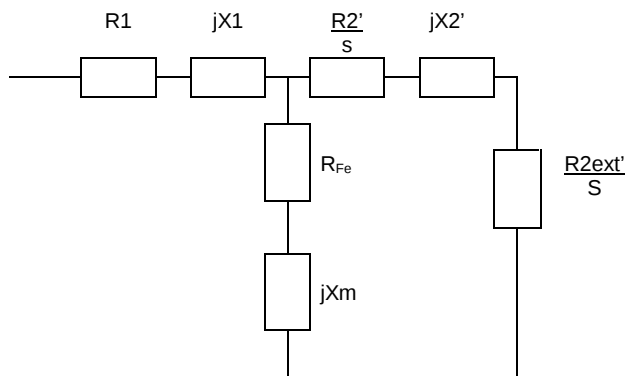
|       |   |      |
|-------|---|------|
| D-end | : | 40 K |
| N-end | : | 50 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 90 K  |
| Rotor  | : | 100 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00347 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.0583 $\Omega$   |
| Rotor resistance, internal | : | $R'_2$                   | 0.0049 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.00817 $\Omega$  |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0605 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0648 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.0956 $\Omega$   |
| Magnetizing reactance      | : | $X_m$                    | 2.13 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 50 Hz             |



### 3.19 Generator Data, Leroy Somer 600 kW, 60 Hz

|                                               |   |                                                                                             |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |
| Manufacturer                                  | : | Leroy Somer FLSB 400 LKC                                                                    |
| Building size                                 | : | 400                                                                                         |
| Degree of protection                          | : | IP54                                                                                        |
| Insulation class (stator/rotor)               | : | H/H (Nameplate can by mistake state F/H)                                                    |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |
| Voltage                                       | : | 3 x 690 V                                                                                   |
| Frequency                                     | : | 60 Hz                                                                                       |
| Number of poles                               | : | 4                                                                                           |
| Rated speed                                   | : | 1890 RPM                                                                                    |
| Slip regulation interval                      | : | 1-10 %                                                                                      |
| Rated Slip                                    | : | 5 %                                                                                         |
| Rated power output                            | : | 600 kW                                                                                      |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |
| 1/1 load                                      | : | 0.89                                                                                        |
| 3/4 load                                      | : | 0.88                                                                                        |
| 1/2 load                                      | : | 0.84                                                                                        |
| 1/4 load                                      | : | 0.66                                                                                        |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |
| 1/1 load                                      | : | 95                                                                                          |
| 3/4 load                                      | : | 95                                                                                          |
| 1/2 load                                      | : | 94                                                                                          |
| 1/4 load                                      | : | 90                                                                                          |
| Generator no load loss                        | : | 17 kW                                                                                       |
| Generator current                             |   |                                                                                             |
| full load                                     | : | 563 A                                                                                       |
| no load                                       | : | 150 A                                                                                       |
| Generator reactive power                      |   |                                                                                             |
| full load                                     | : | 304 kVAr                                                                                    |
| no load                                       | : | 179 kVAr                                                                                    |
| Power factor correction                       | : | 175-225 kVAr, regulated 150-250 kVAr, regulated                                             |
| Resulting power factor (average on grid side) |   |                                                                                             |
| 1/1 load                                      | : | 0.99 1.0                                                                                    |
| 3/4 load                                      | : | 1.0 1.0                                                                                     |
| 1/2 load                                      | : | 0.99 1.0 (200 kVAr)                                                                         |
| 1/4 load                                      | : | 1.0 0.99 (150 kVAr)                                                                         |
| Resulting full load current (grid side):      | : | 506 A                                                                                       |
| Locked rotor                                  | : | short-circuited 100 % external                                                              |
|                                               |   | rotor resistance                                                                            |
| Stator current                                | : | 3600 A 2820                                                                                 |
| Power factor                                  | : | 0.1 0.7                                                                                     |
| Torque ( $T_s/T_N$ )                          | : | 0.33 1.7                                                                                    |
| Rated torque $T_N$ (5 % slip)                 | : | 3191 Nm                                                                                     |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestels</b>     | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.6                    |
| motor                               | : | 2.9                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2460 V                 |
| Rated rotor current per system      | : | 147 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 91 dB(A)               |
| Air flow from fan                   | : | 7800 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C3 |
| N-end | : | 6324 C3 |

Axial run-out of inner ring :  $\leq 9\mu\text{m}$

Radial run-out of inner ring :  $\leq 13\mu\text{m}$

Temperature rise bearings:

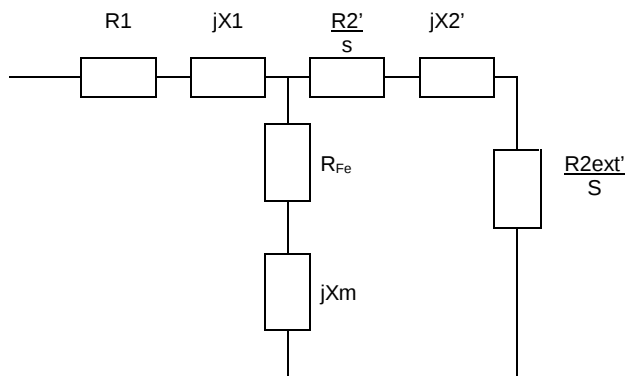
|       |   |      |
|-------|---|------|
| D-end | : | 40 K |
| N-end | : | 50 K |

Temperature rise windings (hot spot)

|        |   |      |
|--------|---|------|
| Stator | : | 90 K |
| Rotor  | : | 95 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.0034 $\Omega$   |
| Stator reactance           | : | $X_1$                    | 0.068 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.0045 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0083 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0593 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.078 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$                 | 0.110 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.58 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 60 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.20 Generator Data, Leroy Somer 660 kW, 60 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Leroy Somer FLSB 400 LKC                                                                    |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | H/H (Nameplate can by mistake state F/H)                                                    |                           |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 60 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1890 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.89                                                                                        |                           |
| 3/4 load                                      | : | 0.88                                                                                        |                           |
| 1/2 load                                      | : | 0.84                                                                                        |                           |
| 1/4 load                                      | : | 0.66                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 90                                                                                          |                           |
| Generator no load loss                        | : | 17 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 618 A                                                                                       |                           |
| no load                                       | : | 150 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 331 kVAr                                                                                    |                           |
| no load                                       | : | 179 kVAr                                                                                    |                           |
| Power factor correction                       | : | 175-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (average on grid side) |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 0.99                      |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 0.99                                                                                        | 1.0 (200 kVAr)            |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| Resulting full load current (grid side):      |   | 559 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3600 A                                                                                      | 2820                      |
| Power factor                                  | : | 0.1                                                                                         | 0.7                       |
| Torque ( $T_S/T_N$ )                          | : | 0.3                                                                                         | 1.5                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3510 Nm                                                                                     |                           |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestels</b>     | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 2.4                    |
| motor                               | : | 2.6                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2460 V                 |
| Rated rotor current per system      | : | 162 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 29 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 91 dB(A)               |
| Air flow from fan                   | : | 7800 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6324 C3 |
| N-end | : | 6324 C3 |

Axial run-out of inner ring :  $\leq 9\mu\text{m}$

Radial run-out of inner ring :  $\leq 13\mu\text{m}$

Temperature rise bearings:

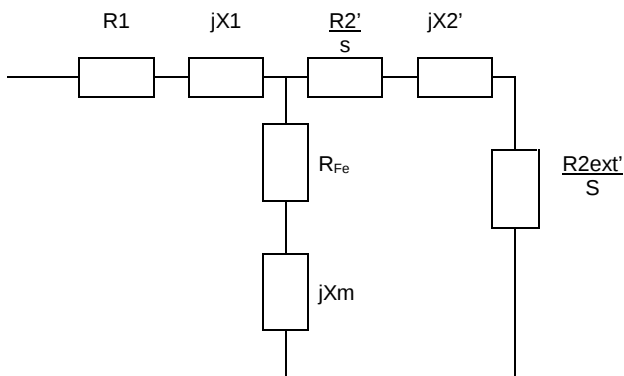
|       |   |      |
|-------|---|------|
| D-end | : | 40 K |
| N-end | : | 50 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 100 K |
| Rotor  | : | 105 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.0034 $\Omega$   |
| Stator reactance           | : | $X_1$                    | 0.068 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.0045 $\Omega$   |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0083 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0593 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.078 $\Omega$    |
| Iron loss                  | : | $R_{Fe}$                 | 0.110 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.58 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 60 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.21 Generator Data, Siemens 600 kW, 50 Hz

|                                               |   |                                                                                             |                 |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|-----------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                 |
| Manufacturer                                  | : | Siemens, type 1PS8 408 - 4ZZ90-Z                                                            |                 |
| Building size                                 | : | 400                                                                                         |                 |
| Degree of protection                          | : | IP54                                                                                        |                 |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                 |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |                 |
| Voltage                                       | : | 3 x 690 V                                                                                   |                 |
| Frequency                                     | : | 50 Hz                                                                                       |                 |
| Number of poles                               | : | 4                                                                                           |                 |
| Rated speed                                   | : | 1575 RPM                                                                                    |                 |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                 |
| Rated Slip                                    | : | 5 %                                                                                         |                 |
| Rated power output                            | : | 600 kW                                                                                      |                 |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                 |
| 1/1 load                                      | : | 0.90                                                                                        |                 |
| 3/4 load                                      | : | 0.89                                                                                        |                 |
| 1/2 load                                      | : | 0.84                                                                                        |                 |
| 1/4 load                                      | : | 0.65                                                                                        |                 |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                 |
| 1/1 load                                      | : | 95                                                                                          |                 |
| 3/4 load                                      | : | 95                                                                                          |                 |
| 1/2 load                                      | : | 94                                                                                          |                 |
| 1/4 load                                      | : | 91                                                                                          |                 |
| Generator no load loss                        | : | 10 kW                                                                                       |                 |
| Generator current                             |   |                                                                                             |                 |
| full load                                     | : | 558 A                                                                                       |                 |
| no load                                       | : | 151 A                                                                                       |                 |
| Generator reactive power                      |   |                                                                                             |                 |
| full load                                     | : | 290 kVAr                                                                                    |                 |
| no load                                       | : | 180 kVAr                                                                                    |                 |
| Power factor correction                       | : | 175-225 kVAr, regulated 200-250 kVAr, regulated                                             |                 |
| Resulting power factor (average on grid side) |   |                                                                                             |                 |
| 1/1 load                                      | : | 0.99                                                                                        | 1.0             |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0             |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)  |
| 1/4 load                                      | : | 1.0                                                                                         | 0.99 (200 kVAr) |
| Resulting full load current (grid side):      | : | 505 A                                                                                       |                 |
| Locked rotor                                  | : | short-circuited rotor 100 % external resistance                                             |                 |
| Stator current                                | : | 4550 A                                                                                      | 3000 A          |
| Power factor                                  | : | 0.05                                                                                        | 0.68            |
| Torque ( $T_S/T_N$ )                          | : | 0.50                                                                                        | 4.0             |
| Rated torque $T_N$ (5 % slip)                 | : | 3829 Nm                                                                                     |                 |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 4.3                    |
| motor                               | : | 3.9                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2355 V                 |
| Rated rotor current per system      | : | 149 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 31 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 85 dB(A)               |
| Air flow from fan                   | : | 4700 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6226 C4 |
| N-end | : | 6226 C3 |

Temperature rise bearings:

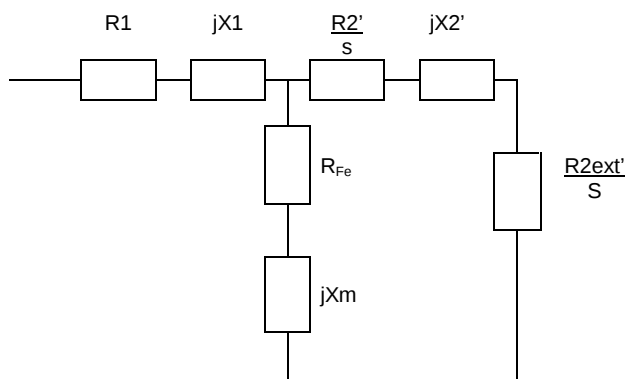
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|-------|---|------|
| D-end | : | 45 K |
| N-end | : | 44 K |

Temperature rise windings (hot spot)

|        |   |      |
|--------|---|------|
| Stator | : | 70 K |
| Rotor  | : | 95 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00393 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.050 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.00467 $\Omega$  |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0070 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0623 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0547 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.055 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.60 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.22 Generator Data, Siemens 660 kW, 50 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Siemens, type 1PS8 408 – 4ZZ90-Z                                                            |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                           |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 50 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1575 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 660 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.91                                                                                        |                           |
| 3/4 load                                      | : | 0.89                                                                                        |                           |
| 1/2 load                                      | : | 0.84                                                                                        |                           |
| 1/4 load                                      | : | 0.65                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 91                                                                                          |                           |
| Generator no load loss                        | : | 10 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 607 A                                                                                       |                           |
| no load                                       | : | 151 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 301 kVAr                                                                                    |                           |
| no load                                       | : | 180 kVAr                                                                                    |                           |
| Power factor correction                       | : | 175-225 kVAr, regulated                                                                     | 200-250 kVAr, regulated   |
| Resulting power factor (average on grid side) |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.99                                                                                        | 1.0                       |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0                       |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| Resulting full load current (grid side):      |   | 556 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 4550 A                                                                                      | 3000                      |
| Power factor                                  | : | 0.05                                                                                        | 0.68                      |
| Torque ( $T_S/T_N$ )                          | : | 0.45                                                                                        | 3.7                       |
| Rated torque $T_N$ (5 % slip)                 | : | 4212 Nm                                                                                     |                           |

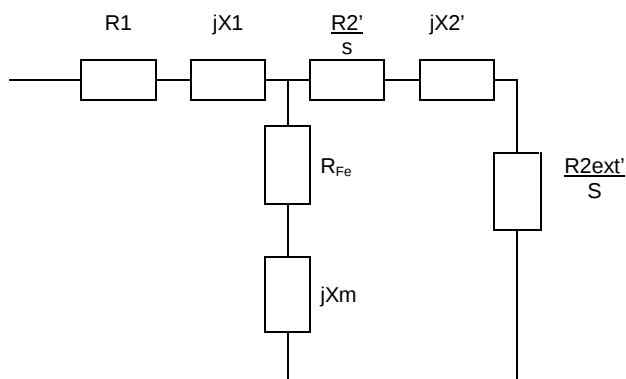
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|--------------------|----------------|---------------------|----------------|
| <b>VESTAS</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                      |   |                        |
|--------------------------------------|---|------------------------|
| generator                            | : | 3.9                    |
| motor                                | : | 3.6                    |
| Number of rotor systems              | : | 1                      |
| Locked rotor voltage (phase-phase):  | : | 2355 V                 |
| Rated rotor current per system       | : | 165 A                  |
| External resistance (per phase)      | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)           | : | 31 kgm <sup>2</sup>    |
| Noise level (1m distance)            | : | 85 dB(A)               |
| Air flow from fan                    | : | 4700 m <sup>3</sup> /h |
| Weights:                             |   |                        |
| Generator                            | : | 3,400 kg               |
| VRCC                                 | : | 45 kg                  |
| Total                                | : | 3,445 kg               |
| Bearings:                            |   |                        |
| D-end                                | : | 6226 C4                |
| N-end                                | : | 6226 C3                |
| Temperature rise bearings:           |   |                        |
| D-end                                | : | 45 K                   |
| N-end                                | : | 44 K                   |
| Temperature rise windings (hot spot) |   |                        |
| Stator                               | : | 79 K                   |
| Rotor                                | : | 105 K                  |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00393 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.050 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.00467 $\Omega$  |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0070 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0623 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0547 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.055 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 2.60 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 50 Hz             |



|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### 3.23 Generator Data, Siemens 600 kW, 60 Hz

|                                               |   |                                                                                             |                           |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|---------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |                           |
| Manufacturer                                  | : | Siemens, type 1PS8 408 – 4ZZ90-Z                                                            |                           |
| Building size                                 | : | 400                                                                                         |                           |
| Degree of protection                          | : | IP54                                                                                        |                           |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |                           |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |                           |
| Voltage                                       | : | 3 x 690 V                                                                                   |                           |
| Frequency                                     | : | 60 Hz                                                                                       |                           |
| Number of poles                               | : | 4                                                                                           |                           |
| Rated speed                                   | : | 1890 RPM                                                                                    |                           |
| Slip regulation interval                      | : | 1-10 %                                                                                      |                           |
| Rated Slip                                    | : | 5 %                                                                                         |                           |
| Rated power output                            | : | 600 kW                                                                                      |                           |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |                           |
| 1/1 load                                      | : | 0.93                                                                                        |                           |
| 3/4 load                                      | : | 0.92                                                                                        |                           |
| 1/2 load                                      | : | 0.90                                                                                        |                           |
| 1/4 load                                      | : | 0.77                                                                                        |                           |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |                           |
| 1/1 load                                      | : | 95                                                                                          |                           |
| 3/4 load                                      | : | 95                                                                                          |                           |
| 1/2 load                                      | : | 94                                                                                          |                           |
| 1/4 load                                      | : | 90                                                                                          |                           |
| Generator no load loss                        | : | 10 kW                                                                                       |                           |
| Generator current                             |   |                                                                                             |                           |
| full load                                     | : | 538 A                                                                                       |                           |
| no load                                       | : | 112 A                                                                                       |                           |
| Generator reactive power                      |   |                                                                                             |                           |
| full load                                     | : | 237 kVAr                                                                                    |                           |
| no load                                       | : | 134 kVAr                                                                                    |                           |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     | 150-250 kVAr, regulated   |
| Resulting power factor (average on grid side) |   |                                                                                             |                           |
| 1/1 load                                      | : | 1.0                                                                                         | 1.0                       |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0 (200 kVAr)            |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0 (150 kVAr)            |
| 1/4 load                                      | : | 1.0                                                                                         | 0.99 (150 kVAr)           |
| Resulting full load current (grid side):      |   | 502 A                                                                                       |                           |
| Locked rotor                                  | : | short-circuited rotor                                                                       | 100 % external resistance |
| Stator current                                | : | 3660 A                                                                                      | 2750                      |
| Power factor                                  | : | 0.08                                                                                        | 0.61                      |
| Torque ( $T_S/T_N$ )                          | : | 0.31                                                                                        | 3.2                       |
| Rated torque $T_N$ (5 % slip)                 | : | 3191 Nm                                                                                     |                           |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>Vestas</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 3.5                    |
| motor                               | : | 3.2                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2355 V                 |
| Rated rotor current per system      | : | 149 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 31 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 89 dB(A)               |
| Air flow from fan                   | : | 5600 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6226 C4 |
| N-end | : | 6226 C3 |

Temperature rise bearings:

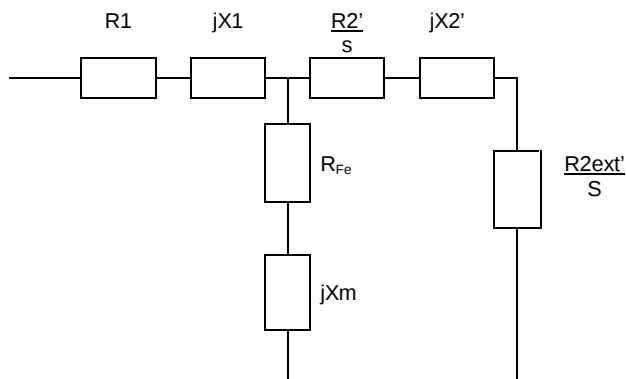
|       |   |      |
|-------|---|------|
| D-end | : | 43 K |
| N-end | : | 33 K |

Temperature rise windings (hot spot)

|        |   |      |
|--------|---|------|
| Stator | : | 67 K |
| Rotor  | : | 90 K |

Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00393 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.060 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.00467 $\Omega$  |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0070 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0623 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0667 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.081 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 3.13 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 60 Hz             |



|                                                                                  |                |   |           |           |
|----------------------------------------------------------------------------------|----------------|---|-----------|-----------|
|  | Generator Data |   |           |           |
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|                                                                                  |                |   | Page:     | 54 of 63  |

### 3.24 Generator Data, Siemens 660 kW, 60 Hz

|                                               |   |                                                                                             |      |                         |
|-----------------------------------------------|---|---------------------------------------------------------------------------------------------|------|-------------------------|
| Generator type                                | : | Three phase asynchronous generator with wound rotor and Vestas rotor current control (VRCC) |      |                         |
| Manufacturer                                  | : | Siemens, type 1PS8 408 – 4ZZ90-Z                                                            |      |                         |
| Building size                                 | : | 400                                                                                         |      |                         |
| Degree of protection                          | : | IP54                                                                                        |      |                         |
| Insulation class (stator/rotor)               | : | F/F                                                                                         |      |                         |
| Winding connection (stator/rotor)             | : | delta/star                                                                                  |      |                         |
| Voltage                                       | : | 3 x 690 V                                                                                   |      |                         |
| Frequency                                     | : | 60 Hz                                                                                       |      |                         |
| Number of poles                               | : | 4                                                                                           |      |                         |
| Rated speed                                   | : | 1890 RPM                                                                                    |      |                         |
| Slip regulation interval                      | : | 1-10 %                                                                                      |      |                         |
| Rated Slip                                    | : | 5 %                                                                                         |      |                         |
| Rated power output                            | : | 660 kW                                                                                      |      |                         |
| Generator power factor (cos $\phi$ ):         |   |                                                                                             |      |                         |
| 1/1 load                                      | : | 0.93                                                                                        |      |                         |
| 3/4 load                                      | : | 0.92                                                                                        |      |                         |
| 1/2 load                                      | : | 0.90                                                                                        |      |                         |
| 1/4 load                                      | : | 0.77                                                                                        |      |                         |
| Generator efficiency (%) (at 2 % slip curve): |   |                                                                                             |      |                         |
| 1/1 load                                      | : | 95                                                                                          |      |                         |
| 3/4 load                                      | : | 95                                                                                          |      |                         |
| 1/2 load                                      | : | 94                                                                                          |      |                         |
| 1/4 load                                      | : | 90                                                                                          |      |                         |
| Generator no load loss                        | : | 10 kW                                                                                       |      |                         |
| Generator current                             |   |                                                                                             |      |                         |
| full load                                     | : | 592 A                                                                                       |      |                         |
| no load                                       | : | 112 A                                                                                       |      |                         |
| Generator reactive power                      |   |                                                                                             |      |                         |
| full load                                     | : | 261 kVAr                                                                                    |      |                         |
| no load                                       | : | 134 kVAr                                                                                    |      |                         |
| Power factor correction                       | : | 125-225 kVAr, regulated                                                                     |      | 150-250 kVAr, regulated |
| Resulting power factor (average on grid side) |   |                                                                                             |      |                         |
| 1/1 load                                      | : | 1.0                                                                                         | 1.0  |                         |
| 3/4 load                                      | : | 1.0                                                                                         | 1.0  |                         |
| 1/2 load                                      | : | 1.0                                                                                         | 1.0  | (150 kVAr)              |
| 1/4 load                                      | : | 1.0                                                                                         | 1.0  | (150 kVAr)              |
| Resulting full load current (grid side):      |   | 553 A                                                                                       |      |                         |
| Locked rotor                                  | : | short-circuited                                                                             |      | 100 % external          |
|                                               |   | rotor                                                                                       |      | resistance              |
| Stator current                                | : | 3660 A                                                                                      | 2750 |                         |
| Power factor                                  | : | 0.08                                                                                        | 0.61 |                         |
| Torque ( $T_S/T_N$ )                          | : | 0.29                                                                                        | 2.9  |                         |
| Rated torque $T_N$ (5 % slip)                 | : | 3510 Nm                                                                                     |      |                         |

|                    |                |                     |                |
|--------------------|----------------|---------------------|----------------|
| <b>VESTAS</b>      | Generator Data |                     |                |
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Break down torque  $T_{\max}/T_N$

|                                     |   |                        |
|-------------------------------------|---|------------------------|
| generator                           | : | 3.2                    |
| motor                               | : | 3.0                    |
| Number of rotor systems             | : | 1                      |
| Locked rotor voltage (phase-phase): | : | 2355 V                 |
| Rated rotor current per system      | : | 165 A                  |
| External resistance (per phase)     | : | 1.0 $\Omega$           |
| Rotor inertia (incl. VRCC)          | : | 31 kgm <sup>2</sup>    |
| Noise level (1m distance)           | : | 89 dB(A)               |
| Air flow from fan                   | : | 5600 m <sup>3</sup> /h |

Weights:

|           |   |          |
|-----------|---|----------|
| Generator | : | 3,400 kg |
| VRCC      | : | 45 kg    |
| Total     | : | 3,445 kg |

Bearings:

|       |   |         |
|-------|---|---------|
| D-end | : | 6226 C4 |
| N-end | : | 6226 C3 |

Temperature rise bearings:

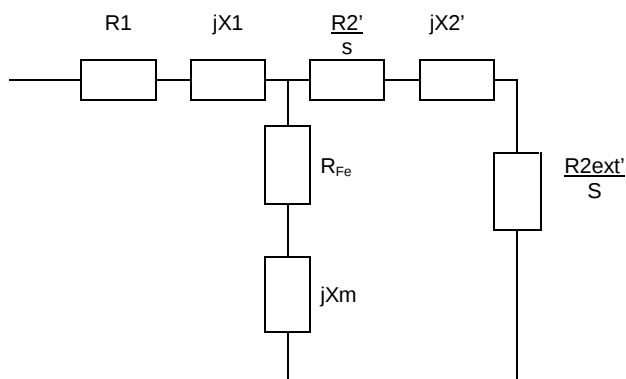
|       |   |      |
|-------|---|------|
| D-end | : | 43 K |
| N-end | : | 33 K |

Temperature rise windings (hot spot)

|        |   |       |
|--------|---|-------|
| Stator | : | 77 K  |
| Rotor  | : | 100 K |

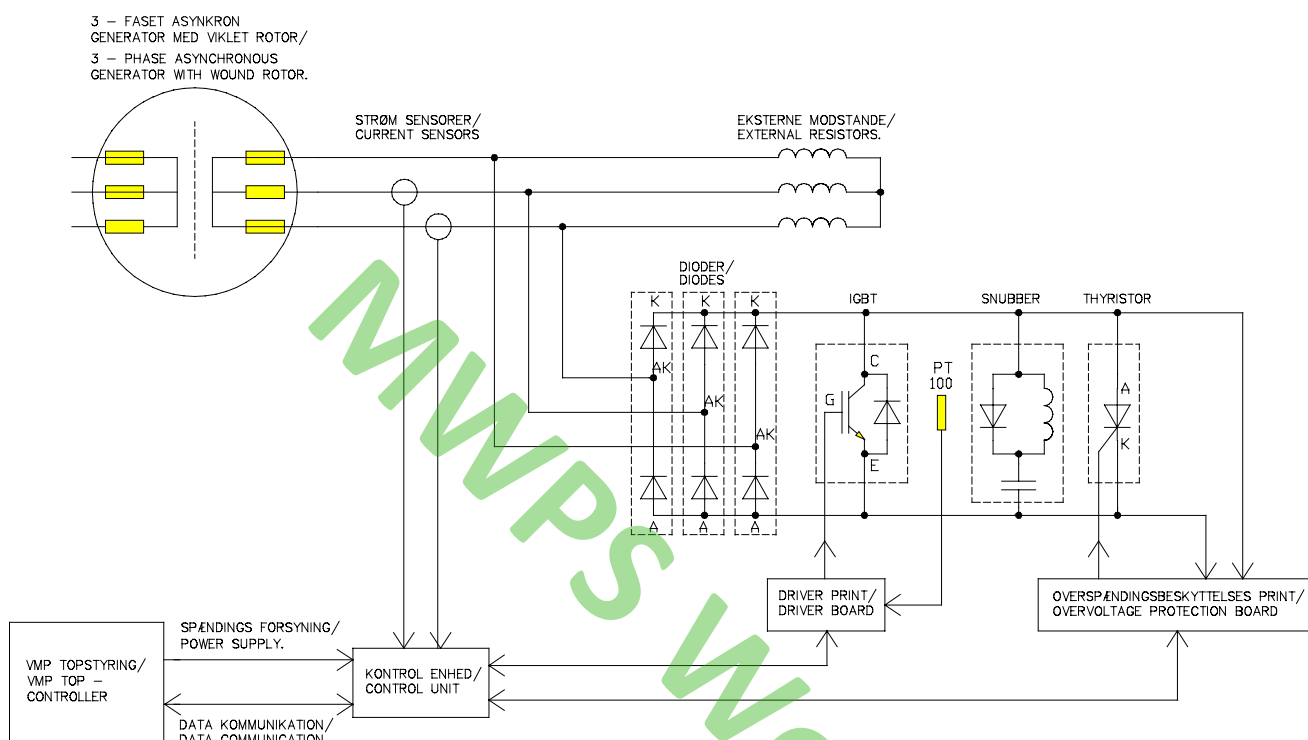
Equivalent diagram (stator side):

|                            |   |                          |                   |
|----------------------------|---|--------------------------|-------------------|
| Stator resistance          | : | $R_1$                    | 0.00393 $\Omega$  |
| Stator reactance           | : | $X_1$                    | 0.060 $\Omega$    |
| Rotor resistance, internal | : | $R'_2$                   | 0.00467 $\Omega$  |
| Rotor res. ext. (2 % slip) | : | $R'_{2 \text{ ext } 2}$  | 0.0070 $\Omega$   |
| Rotor res. ext. (10% slip) | : | $R'_{2 \text{ ext } 10}$ | 0.0623 $\Omega$   |
| Rotor reactance            | : | $X'_2$                   | 0.0667 $\Omega$   |
| Iron loss                  | : | $R_{Fe}$                 | 0.081 $\Omega$    |
| Magnetizing reactance      | : | $X_m$                    | 3.13 $\Omega$     |
| Voltage                    | : | $U$                      | 690 V/ $\sqrt{3}$ |
| Frequency                  | : | $f$                      | 60 Hz             |



### 3.25 Description of VRCC (Vestas Rotor Current Controller)

VRCC is a current control unit which is used for control of the rotor current in an asynchronous generator with wound rotor. The unit is mounted on the generator shaft end in the N-end, and is electrical connected to the three rotor phases. In figure 2 an electrical diagram of the VRCC is shown.



**Figure 2** Electrical diagram of the VRCC.

The VRCC controls the rotor current, which is proportional to the electrical power. From the current reference (sent from the VMP top-controller) and two measured rotor currents, the control unit calculates the necessary resistance. This resistance is achieved by a pulse width modulation of the external resistors by switching the IGBT on and off with a 3 kHz switch frequency.

The VRCC can e.g. maintain rated current (and with that rated power) while the generator slip varies between approximately 0.6% and 10% by adjusting the resistance between 0 and the max. value.

The snubber is used to limit the voltage peak each time the IGBT is switched off.

The thyristor is used for overvoltage protection of the power electronics by short-circuiting the IGBT in case of a short interruption or a short-circuit on the grid.

The VRCC control unit is power supplied from the VMP top-controller. If the power supply is OK, an LED on the VRCC control unit front cover will light red constantly. If no communication has taken place for 1 minute (the turbine is normally at standstill), the power

supply is switched off automatically by the VRCC control unit.. When communication is resumed, the power supply is switched on automatically..

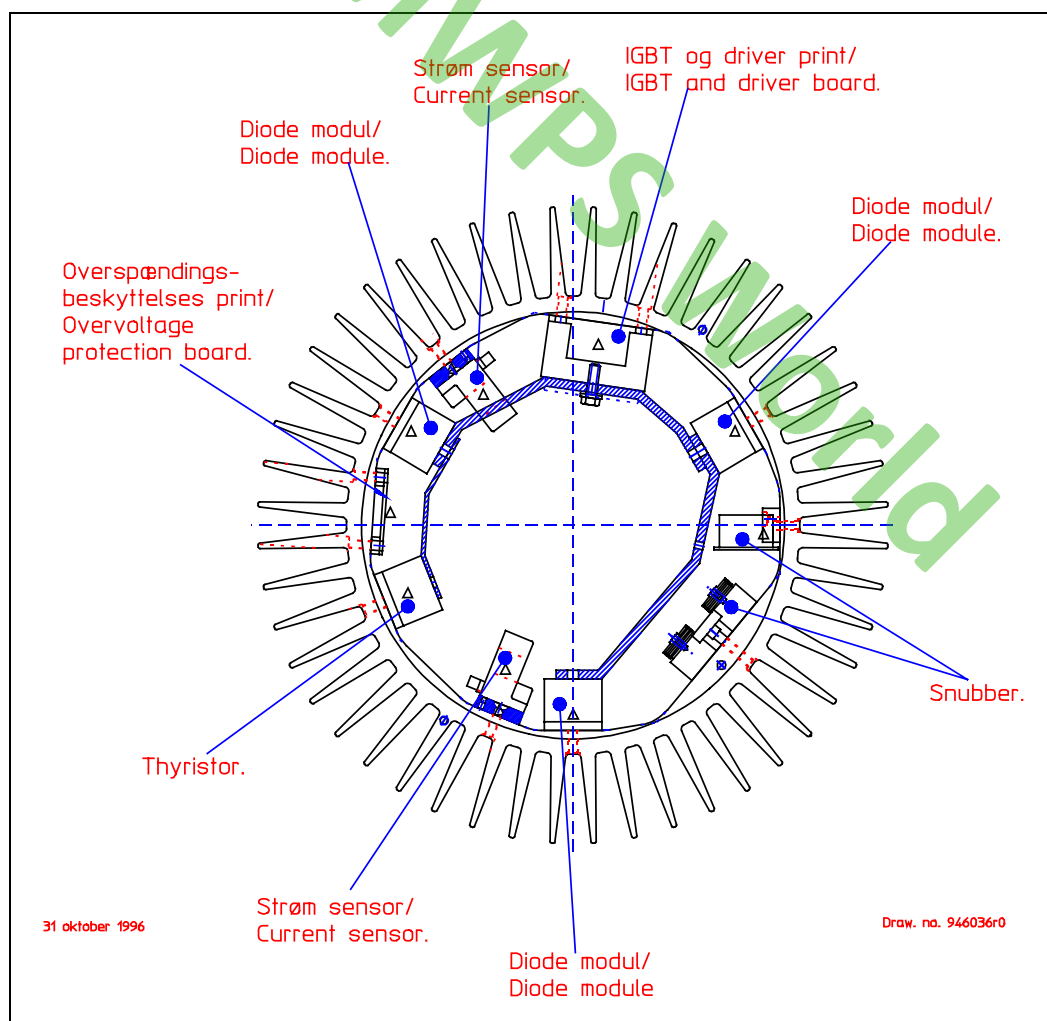
The VRCC control unit is communicating with the VMP top-controller (CT 3514) via a serial, optoelectronic connection. An LED on the VRCC control unit front cover will light red when the VMP-controller transmits data to the VRCC control unit and will light green if the VRCC control unit transmits data to the VMP-controller. The transmission frequency of telegrams to/from the control unit is 10 Hz. If the data transmission is OK in both directions, the colour of the LED will look like yellow.

### 3.25.1 Layout

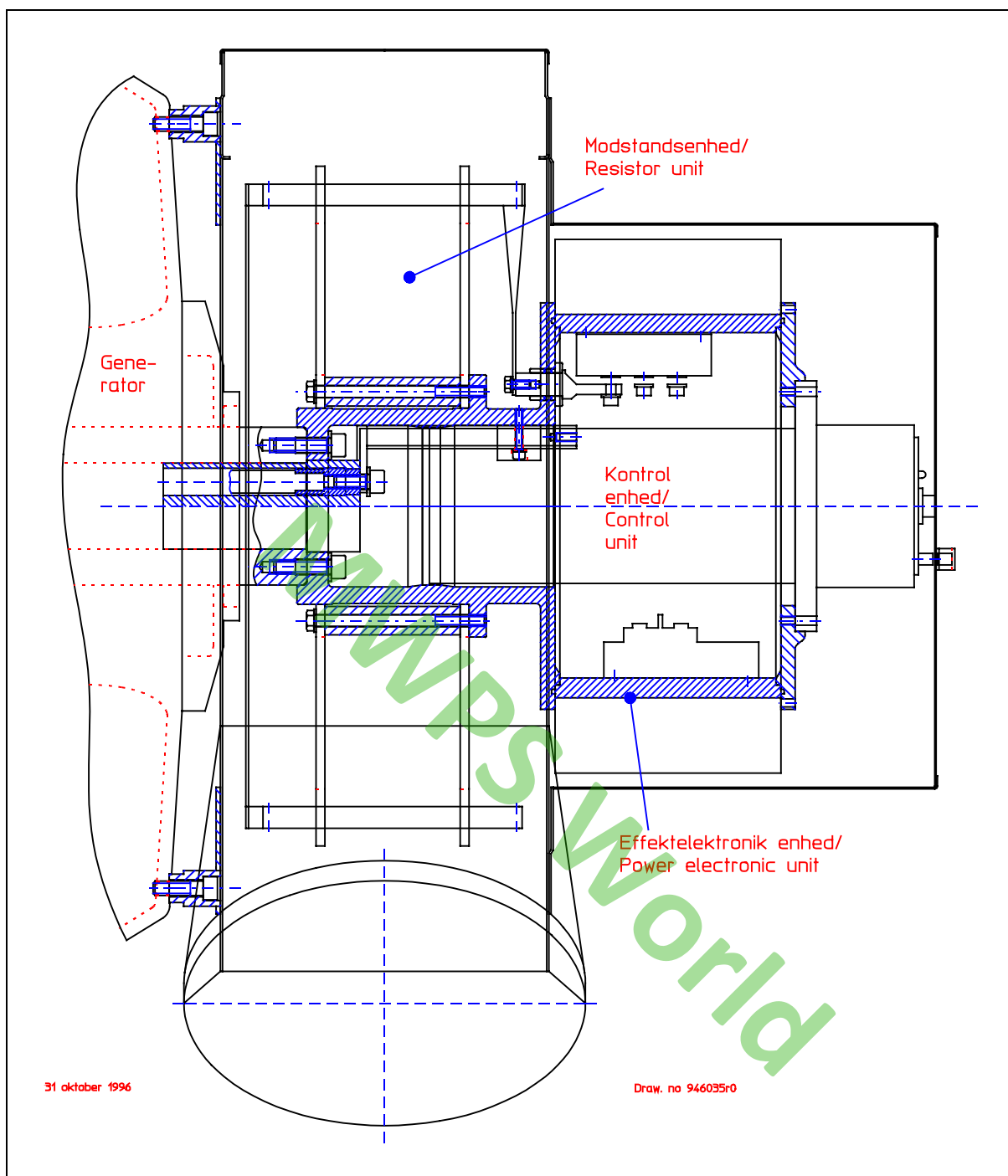
The VRCC can be split into 3 units:

- Resistor unit
- Power electronic unit
- Control unit

In figure 3 and figure 4 drawings of the VRCC are shown.



**Figure 3** VRCC power electronic unit.



**Figure 4** VRCC mounted on the generator.

### 3.25.2 Climatical data

Ambient conditions of the VRCC:

- Min. temperature:  $\pm 20\text{ }^{\circ}\text{C}$
- Max. temperature:  $50\text{ }^{\circ}\text{C}$
- Humidity:  $< 100\text{ }\%$
- Corrosion class: 2

### 3.25.3 Mechanical data

- Rated slip: 5 %
- Max. speed: 2700 RPM for 1 min
- Vibration class: Q 6.3
- Protection class for the power electronic and control unit: IP54
- The VRCC is self-cooling as the resistor unit and the cover are built up like a tangential fan.
- By turning the middle part of the cover 180°, the VRCC can operate in both directions.
- Moment of inertia: 4 kgm<sup>2</sup>
- Weights:
 

|                        |             |
|------------------------|-------------|
| Resistor unit:         | 12 kg       |
| Power electronic unit: | 16 kg       |
| Control unit:          | <u>4 kg</u> |
| Total rotating weight: | 32 kg       |
| <br>Cover:             | <br>13 kg   |

### 3.25.4 Electrical data

The following rated values are valid within the control limits:

Resistor unit (AC side):

|                                           | 600 kW              | 660 kW              |
|-------------------------------------------|---------------------|---------------------|
| • Resistance:                             | 1.0 Ω/phase         | 1.0 Ω/phase         |
| • Inductance in resistors:                | 1.8 μH/phase        | 1.8 μH/phase        |
| • Rated power at 5% slip:                 | 28 kW               | 30 kW               |
| • Rated rms voltage at 5% slip:           | 107 V (phase-phase) | 108 V (phase-phase) |
| • Rated rms current (rated grid voltage): | 150 A               | 165 A               |
| • Max rms current (-10% grid voltage):    | 173 A               | 187 A               |
| • Current limit (rms value):              | 234 A               | 234 A               |

Power electronic unit (DC side):

|                                      |       |       |
|--------------------------------------|-------|-------|
| • Rated rms voltage at 5% slip:      | 144 V | 146 V |
| • Peak voltage during switching off: | 536 V | 579 V |
| • Rated current at 2 % slip:         | 188 A | 212 A |
| • Max. current at 2 % slip:          | 217 A | 240 A |
| • Current limit (peak value):        | 330 A | 330 A |
| • Voltage limit (peak value):        | 950 V | 950 V |

Control unit:

- Power supply: 24 VAC, max 3 A or 32 VDC, max. 1.5 A
- Communication: RS 422
- Control voltage to IGBT driver: 5 V

|                                                                                  |                |                     |       |          |
|----------------------------------------------------------------------------------|----------------|---------------------|-------|----------|
|  | Generator Data |                     |       |          |
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### 3.25.5 Thermal data

The temperature of the IGBT mounting plate and the internal temperature of the control unit are monitored by the control unit. Temperature limits:

- max. temperature: 80°C
- min. temperature:  $\pm 25^{\circ}\text{C}$

MWPS World

## 4. Generator 2, V47

### 4.1 200 kW ABB Generator, 50 Hz

|                                        |   |                                                 |
|----------------------------------------|---|-------------------------------------------------|
| Generator type                         | : | Asynchronous generator with short-circuit rotor |
| Manufacturer and type                  | : | M2CG 280MB 4                                    |
| Building size                          | : | 280                                             |
| Degree of protection                   | : | IP54                                            |
| Insulation class                       | : | F                                               |
| Winding connection (stator)            | : | Y                                               |
| Voltage                                | : | 3 x 690 V                                       |
| Frequency                              | : | 50 Hz                                           |
| Number of poles                        | : | 4                                               |
| No-load current                        | : | 42 A                                            |
| Locked rotor                           |   |                                                 |
| stator current $I_s$                   | : | 940 A                                           |
| power factor $\cos\phi_s$              | : | 0.31                                            |
| Reactive power at no load              | : | 50 kVAr                                         |
| Bearings:                              |   |                                                 |
| D-end                                  | : | 6316 C3                                         |
| N-end                                  | : | 6316 C3                                         |
| Weight                                 | : | 580 kg                                          |
| Moment of inertia                      | : | 1.15 kgm <sup>2</sup>                           |
| <u>S2 operation</u>                    |   |                                                 |
| Power                                  | : | 200 kW                                          |
| Current                                | : | 195 A                                           |
| Power factor                           | : | 0.87                                            |
| Reactive power                         | : | 113 kVAr                                        |
| Efficiency                             | : | 94.1 %                                          |
| Speed                                  | : | 1521 rpm                                        |
| Slip                                   | : | 1.4 %                                           |
| Starting torque (as a motor) $T_s/T_n$ | : | 1.0                                             |
| Breakdown torque $T_{max}/T_n$         | : | 2.1                                             |
| Temperature rise                       | : |                                                 |
| Stator windings (hot spot)             | : | 73 K                                            |
| Bearing D-end                          | : | 25 K                                            |

|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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### S1 operation

|                                        |   |          |
|----------------------------------------|---|----------|
| Power                                  | : | 130 kW   |
| Current                                | : | 130 A    |
| Power factor                           | : | 0.85     |
| Reactive power                         | : | 81 kVAr  |
| Efficiency                             | : | 94.3 %   |
| Speed                                  | : | 1516 rpm |
| Slip                                   | : | 1.1 %    |
| Starting torque (as a motor) $T_s/T_n$ | : | 1.6      |
| Breakdown torque $T_{max}/T_n$         | : | 3.3      |
| Temperature rise:                      |   |          |
| Stator windings (hot spot)             | : | 92 K     |
| Bearing D-end                          | : | 54 K     |

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|                                                                                  |                |                     |                |
|----------------------------------------------------------------------------------|----------------|---------------------|----------------|
|  | Generator Data |                     |                |
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## 4.2 200 kW ABB Generator, 60 Hz

|                             |   |                                                 |
|-----------------------------|---|-------------------------------------------------|
| Generator type              | : | Asynchronous generator with short-circuit rotor |
| Manufacturer and type       | : | ABB M2CG 280MB 4                                |
| Building size               | : | 280                                             |
| Degree of protection        | : | IP54                                            |
| Insulation class            | : | F                                               |
| Winding connection (stator) | : | Y                                               |
| Voltage                     | : | 3 x 690 V                                       |
| Frequency                   | : | 60 Hz                                           |
| Number of poles             | : | 4                                               |
| No-load current             | : | 29 A                                            |
| Locked rotor:               |   |                                                 |
| stator current $I_s$        | : | 900 A                                           |
| power factor $\cos\phi_s$   | : | 0.21                                            |
| Reactive power at no load   | : | 35 kVAr                                         |
| Bearings:                   |   |                                                 |
| D-end                       | : | 6316 C3                                         |
| N-end                       | : | 6316 C3                                         |
| Weight                      | : | 580 kg                                          |
| Moment of inertia           | : | 1.7 kgm <sup>2</sup>                            |

### S2 operation

|                                        |   |          |
|----------------------------------------|---|----------|
| Power                                  | : | 200 kW   |
| Current                                | : | 195 A    |
| Power factor                           | : | 0.87     |
| Reactive power                         | : | 113 kVAr |
| Efficiency                             | : | 94.4     |
| Rated speed                            | : | 1825 rpm |
| Slip                                   | : | 1.4 %    |
| Starting torque (as a motor) $T_s/T_n$ | : | 0.8      |
| Breakdown torque $T_{max}/T_n$         | : | 2.1      |
| Temperature rise:                      |   |          |
| Stator windings (hot spot)             | : | 66 K     |
| Bearing D-end                          | : | 26 K     |

### S1 operation

|                                        |   |          |
|----------------------------------------|---|----------|
| Power                                  | : | 130 kW   |
| Current                                | : | 125 A    |
| Power factor                           | : | 0.87     |
| Reactive power                         | : | 74 kVAr  |
| Efficiency                             | : | 95.2     |
| Rated speed                            | : | 1818 rpm |
| Slip                                   | : | 1.0 %    |
| Starting torque (as a motor) $T_s/T_n$ | : | 1.2      |
| Breakdown torque $T_{max}/T_n$         | : | 3.1      |
| Temperature rise:                      |   |          |
| Stator winding (hot spot)              | : | 76 K     |
| Bearing D-end                          | : | 37 K     |