

## Generator repair in workshop

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## 1 PURPOSE

The purpose of this document is the definition of the technical requirements for a potential frame agreement with subject the repair of generators in workshop.

## 2 PREMISES

ERG Power Generation (hereafter also referred to as “ERG”) owns wind farms in Europe (Italy, France and Germany); for more information with regard to the location and about generators and bearings gearing the wind farms please refer to attached excel file called “WF Generators\_Bearings”.

## 3 SCOPE OF WORK

The scope of this technical specification is to define the repair activities in workshop the above mentioned generators.

Each activity herebelow described is agreed inclusive of all required items, materials and relevant services as indicated in following paragraphs and shall include any other accessory, additional equipment, additional services which Supplier deems necessary for the good performance and the smooth, trouble free and safe execution of the activity.

All the followings have to be considered included into the SOW:

- small parts and consumable;
- cooling liquids;
- supply and filling of any lube (oil, grease, etc);

"Delivery Order" means the document by means of which, ERG will order from time to time supplies and services under the potential frame agreement which will detail the following specifications:

- services requested;
- informations about the generator(s) to be repaired;
- company requesting the services;
- invoicing details;
- address and date of pick up;
- logistic and technical reference for ERG.

### 3.1 TECHNICAL SPECIFICATION OF THE SERVICE

The framework agreement includes the following activities:

#### 3.1.1 GENERATOR DISASSEMBLY AND CLEANING

The supplier shall inform in writing ERG before the beginning of the disassembly of the generator. Any disassembly activities cannot be performed if not duly authorized by ERG in writing. ERG (his representative and/or insurance experts included) has the right to attend to the disassembly activity in the supplier workshop. The disassembly of the generator shall include:

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- semi-joint disassembly;
- NDE Housing disassembly;
- cooling system disassembly;
- eventual rests and labyrinth disassembly;
- rotor extraction;
- ventilation channels and pack cleaning, repeated windings cleaning using a hydro polishing-machine;
- cleaning and inspection of the pipes inner side, motors overhaul;
- furnace drying up.

Small parts and consumable necessary for the disassembly shall be included in the scope of the works and in the related activity pricing.

### 3.1.2 MEASUREMENTS, TESTS, ANALYSIS AND DIAGNOSIS OF THE GENERATOR

After the disassembly the following tests and measurements shall be carried out:

- Mechanical tests:
  - check of the alignment of shaft, bearings, fan and joint;
  - dimensional check of the shaft and shields;
  - dimensional controls of the shaft to find out any interferences for the rolling bearings;
  - general and dimensional controls of all the mechanic parts: bearings, shields seating, labyrinth seals, ecc.;
  - check of the dynamic balancing of the rotor
- Electrical tests:
  - insulation resistance measurement (phases-earth and phases-phases) with megger (at 1000 V c.c.): the measurement shall be carried out on all the windings of stator (one or eventual more windings) and rotor;
  - polarization index measurement (at 1000 V c.c.): the measurement shall be carried out on all the windings of stator (one or eventual more windings) and rotor;
  - resistance measurements on stator windings (U-V-W); the measurement shall be carried on all the windings of stator (one or eventually more windings);
  - resistance measurements on rotor windings (K-L-M);
  - "surge test" for stator and rotor windings: the measurement shall be carried on all the windings of stator (one or eventually more windings) and rotor;
  - loop test to control the magnetic sheets in the magnetic pack;
  - efficiency remark of the heaters, thermometers, PT100 and other generator instrumentation at 500 V c.c.;
  - bearings insulation control;
  - dielectric rigidity tests;
- Visual check:
  - the visual inspection of the general status of the generator is required;

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- visual inspection of the windings heads insulation, of the internal cables, of the main and auxiliary connecting terminals, of the stator magnetic pack and its system;
  - coppers control;
  - control of the PT cables and pertinent connections to the winding and to the terminals;
  - visual inspection of the rotor magnetic pack and its system (or of the squirrel cage), visual inspection of the shaft parts and of the internal fans;
  - visual inspection of the joint and controls of eventual deformations.
- Analysis (RCA) and reporting:  
After the execution of all the measurements and inspections, it is required the analysis of the executed tests and controls (included eventual further anomalies and relevant interventions based on the customers provided specific information). An analysis on the probable cause of the failure shall be carried out.  
The results of the tests, inspections and analyses shall be included into a first report. The report shall be issued in english and sent to the ERG. The report, detailed with pictures, shall include:
    - results of tests (mechanical, electrical and inspection);
    - failures description;
    - determination of probable cause of failure;
    - all the activities necessary to repair the generator (comprised activities not included in the contract);
    - the expected repairing time and costs (with a detailed list of the main components that must be replaced) to appropriately evaluate the damage (for the activities included into this contract shall be applied the price already negotiated inside the contract);

### 3.1.3 REPAIR OF THE GENERATOR

Here below repairs activities to be included in the contract are reported:

#### 3.1.3.1 RECONSTRUCTION OF MAGNETIC STATOMIC PACK

- Reconstruction of the stator magnetic pack using the same material and dimension of the original equipment;

#### 3.1.3.2 RECONSTRUCTION OF MAGNETIC ROTORIC PACK

- Reconstruction of the rotor magnetic pack of the rotor using the same material and dimension of the original equipment;

#### 3.1.3.3 RECONSTRUCTION OF STATOR WINDINGS

- Shields capacity controls;
- dimensional controls of the stator windings;
- demolition of the old stator windings;

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- magnetic pack cleaning to accommodate the new winding;
- construction of a new pack of hanks using batten with the same section size as the original, class H insulated;
- assembling the new pack of hanks;
- coils connections;
- tape insulation of the heads winding;
- previous tests on the stator winding before the impregnation;
- double impregnation (with polyester resin) of the rotor winding in test-tank, using VPI treatment;
- drying with convection oven
- assembly of the exit cables;
- mortising the magnetic pack in the framework;
- assembly of the thermocouples and pertinent cables;
- construction and assembly of new insulating ring and copper terminal;

#### **3.1.3.4 RECONSTRUCTION OF ROTOR WINDINGS**

- shields capacity controls;
- dimensional controls of the rotor windings;
- demolition of the old rotor windings;
- magnetic pack cleaning to accommodate the new winding;
- construction of a new pack of hanks using insulated wire or batten with the same section size as the original, class H insulated;
- assembling the new pack of hanks;
- coils connections;
- tape insulation of the heads winding;
- previous tests on the stator winding before the impregnation;
- double impregnation (with polyester resin) of the rotor winding in test-tank, using VPI treatment;
- drying with convection oven;
- assembly of the exit cables;
- mortising the magnetic pack in the framework;
- assembly of the thermocouples and pertinent cables;
- construction and assembly of new insulating ring and copper terminal;

#### **3.1.3.5 SUPPLY OF NEW BEARINGS**

Supply of new bearings as listed in the excel attached to this technical specification. In particular shall be included the following:

- supply of the bearing front side of the same type already installed;
- supply of the bearing rear side of the same type already installed;
- grease (of the type indicated from the turbine manufacturer or ERG)

The supplier must have in stock at least two bearings for each type indicated in the excel file attached.

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### 3.1.3.6 OTHER REPAIRS ACTIVITIES

If necessary the following activities could be necessary:

- shaft reconstruction, eventual reloading with the same type of steel; (\*)
- bearing housing reconstruction, using a bushing or reloading with the same type of steel; (\*)
- reconstruction of all covers damaged before the arrival in contractor's workshop. (\*)

## 4 MOTOR REASSEMBLY

Complete reassembly with replacements of all the gaskets (insulation materials included). All the small parts and consumable materials (by way of explanation but not limiting: grease, oil, cooling liquid ) necessary for the reassembly shall be included. In this case two prices shall be provided as following:

- 4.1. Reassembly of the repaired generator, including:
  - mounting of new bearings (see 3.1.3.5);
  - dynamic balancing of the rotor;
  - painting (after old painting removal), of the whole generator included all the mechanic parts like shields seating, labyrinth seals, cooling system, etc; subsequent finishing touches with the preexistent color (after bottom paints application);
- 4.2. reassembly of a not repaired generator.

## 5 FINAL TESTS

It is required to carry out the following final tests:

- No load rotation test (full and reduced voltage), with:
  - a. remark of the absorbed currents;
  - b. control of the phases cyclic direction;
  - c. control of eventual noise;
  - d. remark of the vibrations;
  - e. check of bearing temperature.
- Electrical tests on statoric windings:
  - insulation resistance to earth and between the phases with Megger;
  - polarization index;
  - ohmic resistance of the stator;
  - surge test stator winding;
  - Auxiliary circuits control;
  - dielectric strength in c.a. and c.c.
- Electrical tests on rotoric windings (not applicable in case of squirrel cage):
  - insulation resistance to earth and between the phases with Megger;
  - ohmic resistance of the rotor;
  - surge test rotor winding;
  - impedance test on the rotor;
  - auxiliary circuits control.

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- Report: a complete repair report, in English and detailed with pictures, shall be sent. The report shall include:
  - details of the repair activities;
  - results of final tests.

The electrical tests shall be compliant with the standard CEI EN 60034-1.

## 6 TRANSPORT

The transport both “to” and “from” the supplier’s workshop

ERG shall be informed at least 3 working days before the planned date for generator pick up.

All the cost and procedures due to transport permits etc. have to be considered included in the scope of the works.

## 7 DELIVERY TIME

The generators must be delivered to the ERG warehouse )ready for mounting on the wind turbine) within three (3) months since the ERG has issued the Delivery Order.

## 8 MATERIALS SPECIFICATION

All the materials used should be in Class “H”, in particular:

- Electrolytic Copper A ISO 4738 UNI EN 1977 thermic class H+200°C Heat stroke 220°C. Referring norms IEC 60317-13; IEC 60317 -0-1; IEC 60851 1-6.
- Nomex T410 DUPONT ( to earth and head separators)
- Poliglass H200 from Von Roll France SA
- Nomex T410-DUPONT (to earth and head separators)
- Micanite flex 163 with silicone link and polyester film for the electric insulation kV 12 CEI 60371-1;
- Glass-mica Samicapor from Von Roll Francia SA;
- Cable to connect to the commutator type RADOX GKWK voltage rating 3.6/6 kV;
- Impregnation paint in class H polyester (220°C) fr om Dolphs XL-2103 dielectric strength >3200 volts/0.025 mm – ASTM D-3251(twisted cables)

## 9 LAWS, CODES, STANDARDS AND GENERAL SPECIFICATIONS

The design, the manufacturing, installation, commissioning and subsequent start-up of the components are to be carried out following state-of-the-art techniques, and have to conform besides:

- IEC 61400 Series

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- IEC 60034 Series

and to relevant European Italian, French and German laws and rules.

These lists of codes and standards are not to be intended as restrictive and they do not relieve the supplier of his responsibility towards other applicable codes, standards, laws, regulations and safety requirements not mentioned above.