Nidec Power

TECHNICAL NOTE

TN15

GENERAL DESCRIPTION OF LEROY-SOMER™ ALTERNATORS

Since 1919, Nidec Power designed and manufactured rotating machinery, alternators and motors, both synchronous and asynchronous.
Nidec Power now offers a wide range of alternators up to a power of 40,000kVA and voltage level up to 15,000V.

Our alternators are designed and manufactured for efficient and reliable operation in difficult applications and harsh environments, where robustness is of prime importance. The principle industries catered for are marine, oil and gas sectors, mining and energy production sectors, data centers and biomass.

They are suitable for any drive system: gas or steam turbine, diesel or gas engine, wind or hydro turbine. Leroy-Somer™ alternators are compliant with the following standards: IEC, NEMA, CSA, LRS, DNV, BV, ABS. Designs complying with ATEX, CEI ExN & ExP standards are also available.

DESIGN BASIS

Every alternator is designed and customised in accordance with the customer's specification.
Unless otherwise stated, the nominal specifications of the alternator are stated for a nominal ambient temperature less or equal to 40°C and a maximum altitude of 1000 m, for continuous operation (i.e. S1 service).

ISOLATION/TEMPERATURE RISE

All Leroy-Somer™'s alternator windings are manufactured with a Class H insulation system (in accordance with CEI 60085). Refer to Technical Note TN11 - Insulation and Temperature Rise Classes ref. 5202, for more information and for options to increase the service life of these windings.
Leroy-Somer™ alternators can withstand, without damage, a 10% overload for one hour, every 12 hours.

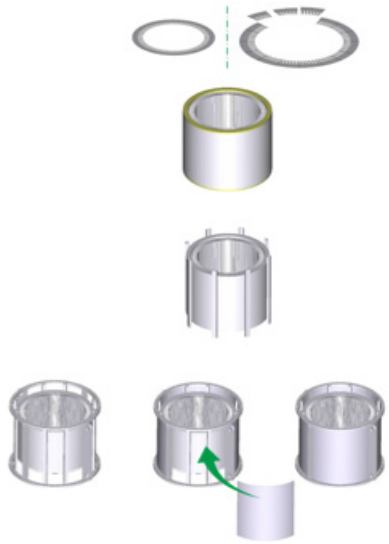
STATOR

The stator is comprised of a core and a winding.

The stator core assembly is constructed from low-loss cold-rolled silicon steel sheets. These are varnished in order to limit losses by Foucault current, cut into a single circle or sections, and stacked around a central mandrel. Radial ventilation ducts, obtained by welding air vents are carefully distributed along the stator core.

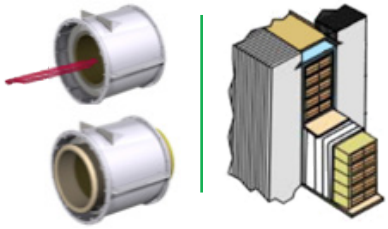
The stator lamination is pressed after stacking and longitudinal bars are welded around its edge.

A frame is welded on bars to complete the assembly. In case of machines with double ventilation (DV), the stator will be inserted into a one-piece casing.



For low voltages, the windings are made from twisted enamelled or stripped round wire under glass silk, depending on the harshness or the pollution of the atmosphere in which the alternator will operate.

The medium and high-voltage windings are made from pre-insulated flattened copper wire. The sections made up of the desired number of turns, shall be insulated under several layers of micaceous tape, before being formed to the desired shape.



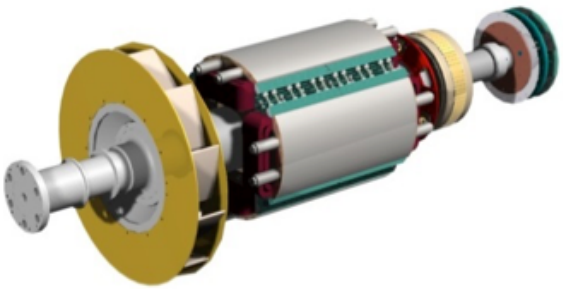
Cross-section of slot Stator MT

The coils are then inserted into the stator slots in a winding procedure referred to as semi-overlapping. The use of Nomex paper (slot channels and insulation between coils) and the jamming of the windings by wedges (intermediate and end wedges) combined with the strengthening of the resistance of the coil heads with Verranne cord, prevents damage to the windings.

The fully wound stator then undergoes a vacuum pressure impregnation process (VPI process).
The stator is dehydrated in an oven in order to eliminate any residual humidity. It is then placed in varnish tank. The air in this tank is sucked out, therefore creating the vacuum and enabling the impregnating resin to be introduced. After a certain period of time, pressurised dry air is introduced into the tank, therefore exerting sufficient pressure so that the resin fills all of the holes that may remain in the insulation.

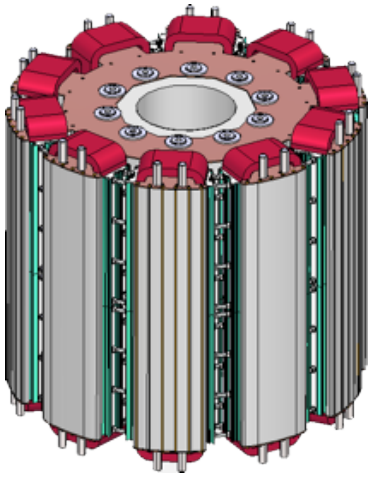
ROTOR

The alternator rotor consists of a shaft, a polar wheel, a fan, a balancing disc, an excitation armature and a rotating bridge rectifier.



The shaft is made from semi-hard steel, produced from a lamination or forged process, depending on the use or customer request.

The polar wheel, referred to as salient pole rotor, consists of a laminated assembly. The integral sheets making up the polar wheel are obtained by press or laser cutting.



The stacking of the polar wheel sheets is finished off with a copper sheet at each end, which is soldered to a bundle of copper bars inserted into each pole shoe (Leblanc type damping cage). This operation is carried out once all of the polar wheel sheets are held in place by a set of tie-rods mounted under pressure. Retaining bars are also added, therefore preventing the winding overhang from being deformed during operation, particularly in the overspeed phases.
The winding is performed by rolling enamelled flattened wire, stripped or wound with silk glass, directly around each pole on the polar wheel.

The coils are held on the poles by wedges which withstand the centrifugal forces and assist in heat dissipation (radiators).

Once the coils are interconnected by soldering, the polar wheel undergoes the vacuum pressure impregnation process (VPI process).
The polar wheel is then mounted on the shaft by a heat-shrinking operation (wheel expands in an oven full regulated by thermocouples, in order to prevent any over-heating that could negatively impact the insulation).

The *exciter armature* is made from stacking cut magnetic sheets. These sheets are riveted into place, then coiled and impregnated.
The *rotating rectifier* consists of 6 large silicon diodes protected by varistors or resistors.

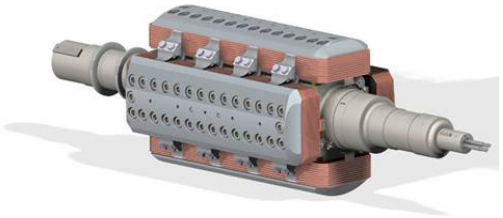
These components and other constituent components of the rotor are mounted by heat-shrinking, wedging and/or key-way on the shaft (*fan*, *balancing disc*, exciter armature and rotating rectifier bridge), and all electrical connections are made.

Balancing of the rotating section is performed dynamically on 2 planes, with G2.5 class balancing adjustments (diesel or gas engines) or G1 class (gas, steam and hydro turbines) in accordance with standard ISO 1940-1.

The rotor assembly is designed to operate below the maximum critical speed with a sufficient safety margin and to withstand an overspeed of 20% for 2 minutes without damage.

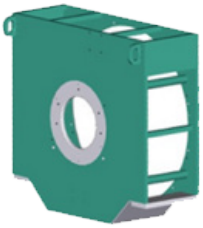
For some specific applications, the overspeed can be greater than 20% for more than 2 minutes.
For specific applications, the rotor is made from a piece of forged steel and the poles are machined directly into the block and the shaft itself.

For the machines LSA 60 / 4P, we apply a special technological variant with separated pole head screwed to the pole core and rotor windings strapped on edge technology.



ASSEMBLY

The alternator is assembled as follows, the rotor is first inserted into the stator. The alternator bearings or spacers are mounted on both sides of the latter, depending on the machine configuration, and will support the bearing or sleeve bearing assemblies.

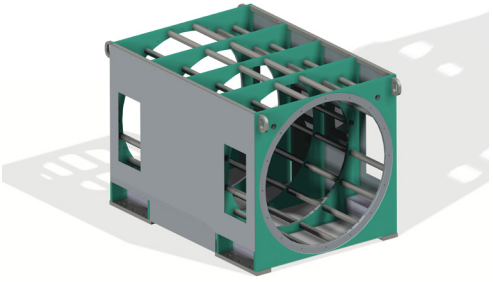


Spacer

Sleeve bearing

Leroy-Somer™ alternators may be single or twin-bearing, with any type of drive shaft end (cylindrical with or without key-way, conical, forged or offset plate, or with transitional rings), to provide the interface with the drive system.
The shaft end may also be extended in the case of a hydro turbine drive when the wheel of the latter is overhanging. In this instance, the bearings are sized to recover the respective forces.
The main forms of construction can be performed in respect of standard CEI 60034-7, with a horizontal or vertical axis of rotation.

For the 4-pole machines with dual ventilation (DV), the impregnated stator is inserted into a one-piece casing. This technology, known as stator winding out of frame, can be applied for some machines in CACA configuration, for example.



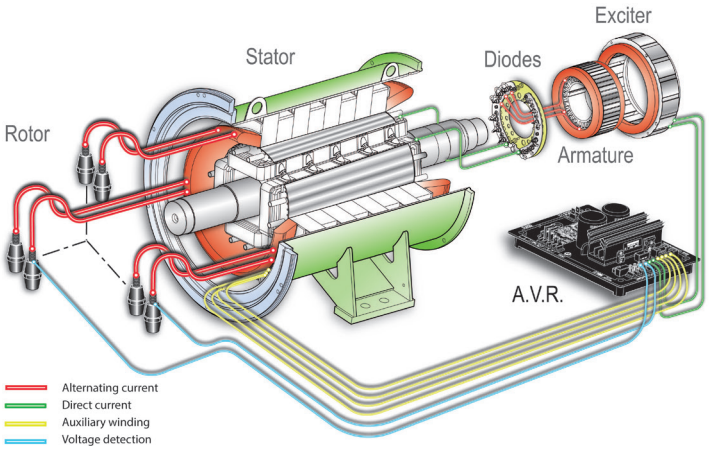
EXCITATION

All Leroy-Somer™ alternators are ringless and brushless with various possible excitation systems: AREP, PMG or Shunt & Booster.

AREP is accompanied by a «PMI» system (i.e. «Permanent Magnet Insert»: permanent magnets mounted on the exciter armature poles). Thanks to this device, providing a sufficient remanent voltage, voltage priming is performed in all circumstances, even after a long shut-down period.

Leroy-Somer™'s patented standard excitation system is the AREP. This excitation system consists of 2 auxiliary windings inserted into the stator slots, close to the main winding.

The first auxiliary winding provides an output power proportional to the stator voltage, the second provides an output power proportional to the stator current.



AUTOMATIC VOLTAGE REGULATOR

Nidec Power offers a regulator in its design, now with digital adjustment (analogue design also available), with communication by field bus. This regulator which works perfectly with the various excitation systems stated above, provides 3 adjustment modes, according to the installation:
- voltage regulation (Un)
- power factor regulation (P.F.)
- reactive power regulation (Q [kVAR])

In the case of an alternator coupled to the network, the regulator also equalizes the alternator voltage on the network before coupling.

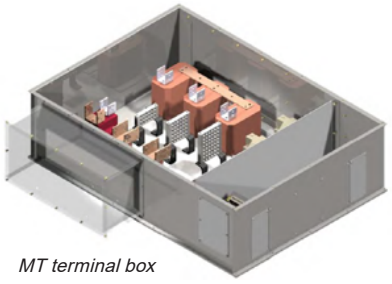
The D700 digital regulator also offers many other functionalities, such as:
- adjustment function [adjust a setting in accordance with another, i.e. Q = f($U_{network}$)]
- synchro-coupler function
- data recorder, etc.

For more information, refer to the information sheet for the D700 digital regulator (ref. 5420).

TERMINAL BOX

A generously-sized and easily-accessible connection box is generally located on the top of the alternator (for a horizontal shaft machine, and standard cooling mode [i.e. without heat exchanger]).

Inside this, the 6 winding ends are connected to connector pads (Low Voltage) or on isolators (Medium and High Voltage), enabling easy connection.



MT terminal box

The current and voltage transformers necessary for the excitation/regulation are also integral, in the same way as well as any other equipment required for customer usage, if the space required is available: current and voltage transformers (safety and measuring), lighting arrestors, coupling capacitors for measuring partial discharge, etc.

The connection terminals are housed in a separate compartment where all of the auxiliary wires are connected (including sensors, probes and other equipment).

The terminal box, whether equipped with an extension or not (i.e. sleeve, in the case of long cable heads, or an angled cable outlet), is provided with a non-drilled non-magnetic plate as standard, necessary for the routing and mounting of power cables.

COOLING SYSTEM

Nidec Power designs its alternators, as standard, with a single ventilation of axial or axial-radial type ; also available on request: dual symmetrical ventilation.

The flow of cooling air comes from the non drive end towards the drive end, guided in the machine in order to increase efficiency, before being expelled radially by the centrifugal fan mounted on the shaft on the coupling side.
This air circulation flow moves in the same direction for a machine with a vertical rotating axis.

Air inlets and outlets are provided on the sides by default, but can be positioned on the upper side or under side, upon request, and depending on the machine configuration.

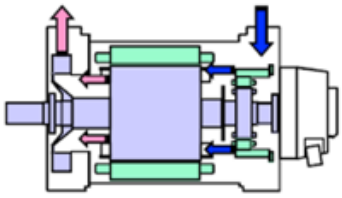
The alternator is cooled directly with ambient air or by an air-to-water or air-to-air heat exchanger.

• COOLING BY AMBIENT AIR

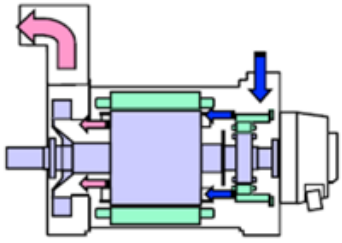
Ambient air is sucked into the alternator on the opposite side of the coupling and across the stator. The air is then expelled from the coupling side.

The temperature of the cold air corresponds to the temperature of the ambient air, which may originate directly from the environment around the alternator (machine room) or perhaps channelled and guided into the alternator by a duct system (outside the power station).

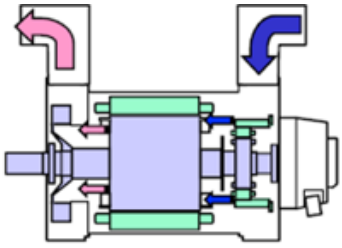
At the machine outlet, the air may also be discharged into the machine room, or outside it, by a duct system.
The main refrigeration indices often supplied, as regards standard CEI 60034-6, are: IC01, IC21 and IC31.



IC01



IC21



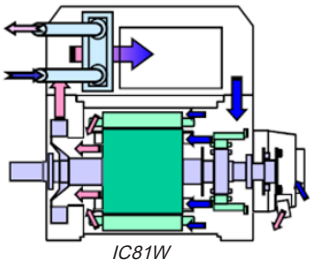
IC31

• COOLING BY AIR-WATER TYPE EXCHANGER (CACW - HYDRO-REFRIGERATED ALTERNATOR)

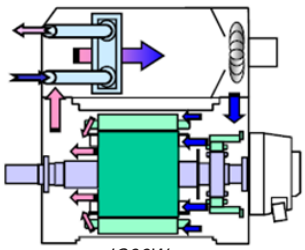
The cooling air (primary fluid) circulates within a closed circuit inside the alternator, thanks to the fan fitted onto the alternator rotor (IC81W). In some circumstances, this fan may be replaced by a motorised fan (IC86W). Hot air is cooled upon contact with the air-to-water exchanger, before moving on again to the alternator.

Water circulation inside the air-to-water exchanger is required to cool the air. This configuration prevents the windings becoming contaminated. The water supply circuit is an open circuit and may be closed in some cases (e.g. circulation performed by a circuit incorporating a water-to-water exchanger in the leak channel of a hydro-electric power station. The cooling water is therefore also cooled by the water, after passing into the turbine).

The materials used to make the air-to-water exchanger depends on the water quality (e.g. freshwater, sea water, amount and size of particles, acidity level, etc.). The construction may consist of single tubes or double tubes.



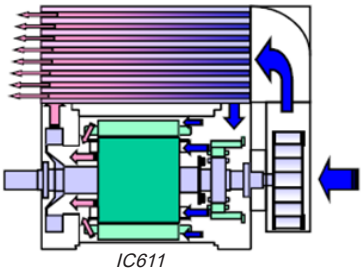
IC81W



IC86W

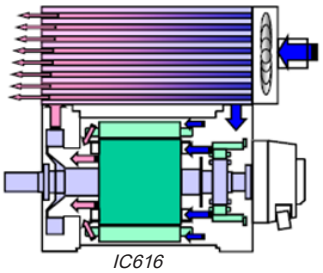
• COOLING BY AIR-TO-AIR EXCHANGER (CACA - AIR COOLED ALTERNATOR)

The cooling air (primary fluid) circulates in a closed circuit inside the alternator, thanks to the fan fixed onto the alternator rotor. Warm air is cooled upon contact with the external casing of the tubes incorporated into the air-to-air exchanger in which the external air circulates (secondary fluid) before passing into the alternator again.



IC611

External air is sucked in by a secondary fan fixed onto the alternator shaft and pushed across the exchanger tube bundle (IC611). In some circumstances, this fan may be replaced by a motorised fan connected to the tube wiring harness bundle inlet (IC616).

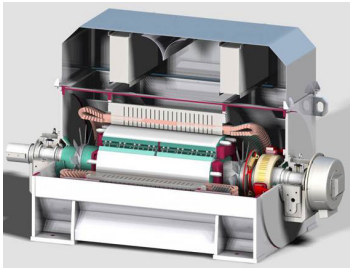


IC616

This configuration also prevents the windings becoming contaminated, but often results in over-sizing of the machine in relation to other cooling modes.

Machines with dual ventilation are a special case. They have symmetrical ventilation and are equipped with two cooling circuits.

In this case, the air enters at both ends and comes out in the middle of the machine.



SLEEVE BEARINGS

Nidec Power offers a twin-bearing configuration with flanged sleeve bearings ([1]).
On certain specific conditions, lubrication of the bearings can be performed by a forced oil circulation device.
In comparison with friction bearings, sleeve bearings offer ease-of-maintenance and longer service life, while oil quality and good lubrication are maintained.
Sleeve bearings are equipped with a visual gauge to check the level of oil in the sump, and can be fitted with temperature sensors (PT100).
The bearing on the coupling side is equipped as standard with thrust bearings for positioning the shaft and to prevent movement towards the coupling, heat expansion occurs in the opposite direction.
The bearing on the opposite side of the coupling is free as standard and insulated to remove any risk of circulation of shaft current.
The bearing on the coupling side can be insulated upon request.

VERTICAL CONFIGURATION

For specific applications, for example, hydro turbines, vertical alternator is needed. In this instance, the upper bearing corresponds to the thrust bearing and supports the shaft and the lower bearing is simply a guide bearing.

THRUST BEARING

For specific applications where specific forces may be exerted on the end of the alternator shaft, the thrust bearing shall be specially sized in accordance with the reinforced thrust-bearing pads, and can be mounted at foot level.
The over-speed conditions are also taken into consideration in the choice of bearings.

[1] default configuration from LSA 56

ACCESSORIES

Other equipment or accessories may be incorporated into the alternator: temperature sensor, reheating.
Temperature sensors can be housed in the stator winding, also in sleeve bearings, and even in the air circuit.
On request, special equipment may be added, for example vibration sensors or overspeed detector, etc.

IP PROTECTION

The protection rating (IP) is typically linked to the cooling configuration and the mechanical arrangement.
An open alternator shall be IP21 or IP23 and may become IP43 with filters or IP44R if connected to ducts, or even IP44, IP54 or IP55 if closed and with an exchanger.
It is possible to provide another protection rating.
Leroy-Somer™ alternators are designed for «indoor» installation but specific «outdoor» design is offered as option.

NOISE LEVEL

Upon special request, it is possible to reduce the noise level by adding sound-proof panels to reach noise legislation.

QUALITY

Leroy-Somer™ products are designed, manufactured and tested at ISO 9001 Ed certified sites. 2000 - NF EN ISO 9001 Ed.2000.
For the customer, the most important aspect is the final test which is performed with reference to a list of standard tests, covering static tests (connections, resistors, insulation, etc.) and rotating tests (no load, with load, in short-circuit, etc.).
A list of optional tests is available to meet the customer's request (temperature rise or reactance measurement test).
The document QUAL/PROC/000 026 provides the details of the inspection points during manufacturing.

Nidec Power strives to provide quality alternators and services to satisfy its customers.