Information Sheet # 53

Total Energy Systems, LLC

Your Reliable Guide for Power Solutions

To fulfill our commitment to be the leading supplier in the power generation industry, the Total Energy Systems, LLC. team ensures they are always up-to-date with the current power industry standards as well as industry trends. As a service, our **Information Sheets** are circulated on a regular basis to existing and potential power customers to maintain their awareness of changes and developments in standards, codes and technology within the power industry.

Alternator Winding Temperature Rise in Generator Systems

1.0 Introduction

When a wire carries electrical current its temperature will increase due to the resistance of the wire. The factor that mostly influences/ limits the acceptable level of temperature rise is the insulation system employed in an alternator. So the hotter the wire, the shorter the life expectancy of the insulation and thus the alternator.

This information sheets discusses how different applications influence temperature rise in alternator windings and classification standards are covered by the National Electrical Manufacturers Association (NEMA).

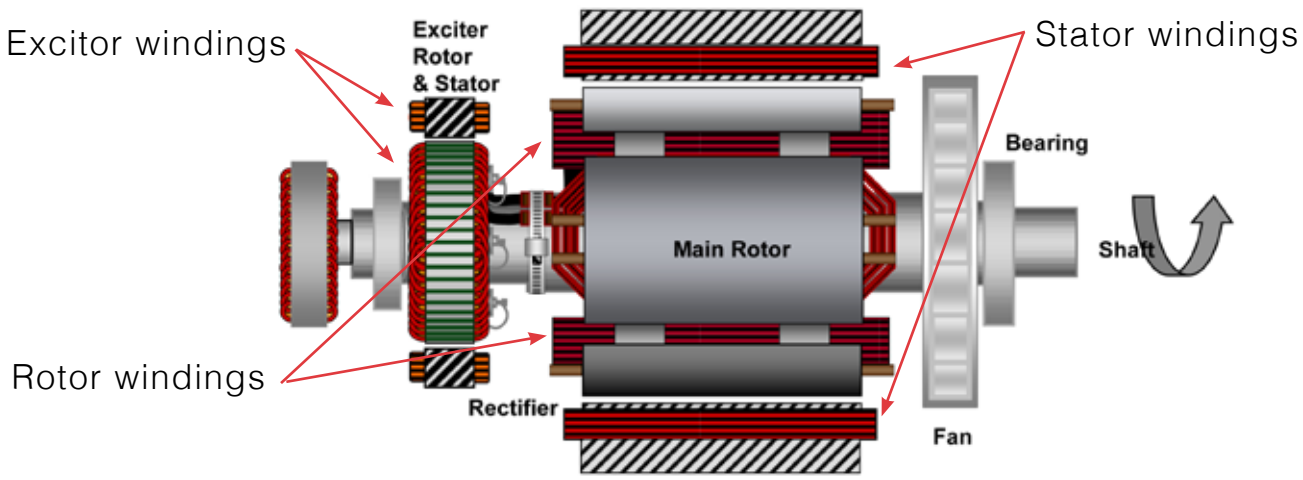
Table 1 - Maximum Temperature Rise (40 °C Ambient)

Continuous				
Temperature Rise	Class A	Class B	Class F	Class H
Temp. Rise °C	60	80	105	125
Temp. Rise °F	108	144	189	225

Table 2 - Maximum Temperature Rise (40 °C Ambient)

Standby				
Temperature Rise	Class A	Class B	Class F	Class H
Temp. Rise °C	85	105	130	150
Temp. Rise °F	153	189	234	270

Typical Windings Within a Generator Set's Alternator



2.0 Classification Standards Covered by NEMA:

(NEMA) Standard MG1, which encompasses the entire machine and includes the requirements for alternator temperature rise. The standard operating ambient temperature in all cases is 40°C (104°F).

Categories. MG1 defines two duty cycles for the alternator:

- **Continuous Duty –** for operation 24-hours a day, 7- days a week, under full load conditions
- **Standby Duty –** for an emergency power source (EPS) - or standby generator set. This is designed to operate as back-up power should the principal power source (utility) be lost or fall outside the nominal frequency or voltage requirements

3.0 Hours Limitation for Temperature Rise:

As the standby category (NEMA MG1 – 22.40) has no defined hour limits, the EPS is considered to typically run for about 200 hours or less a year – considerably fewer than that for a continuous duty application. This higher temperature rise allows more kW to be utilized and is justified by the higher standby output ratings commonly found on most emergency generator sets. However, the insulation of a standby unit will age thermally at about four to eight times that of a continuously rated alternator.

4.0 Insulation Classes: (See chart 1 for classification)

NEMA MG1 recognizes four classes of electrical insulation of the alternator:

- A
- B
- F
- H

Each of these classes have different characteristics, but the accepted common feature is an anticipated minimum life expectancy of 30,000 hours. The letter signifies the maximum allowable windings temperature allowable while the alternator is operating, if exceeded the insulation will breakdown resulting in winding burn out.

See temperature rise Tables 1 (for Continuous Duty) and 2 (for Standby Duty) overleaf

5.0 NEMA Standby Ratings:

As standby duty results in fewer hours of operation, NEMA MG1 allows alternator windings to operate at 25°C higher than for continuous duty applications. If used for continuous duty or prime power, the standby alternator's useful working life will be considerably shortened and reliability may well become an issue.

Most manufacturers of alternators supply the market with Class H insulation, which meets most of the normal applications and duties that are encountered. Many manufacturers will supply insulation class H while meeting class F standby ratings with the same machine.

6.0 Application where a lower winding temperature rise is required:

There are a number of generator applications where a much lower temperature rise is required, in order to handle the type of electrical load and duty cycle.

Prime power applications such as oil field rigs frequently run throughout the year. Heavy-duty cycles usually specify a maximum winding temperature rise of 70°C at 40°C ambient. A lower temperature rise in prime power applications increases reliability with less winding failures because the insulation was subjected to less heat for extended periods.

7.0 Accomplishing Lower Temperature Rises:

The prime factor for a lower temperature rise in all alternators is the size and material of the steel laminations, the length of the lamination stack and the amount of copper wire used. This, added to the design of the amount of cooling air driven through the alternator, will affect the machines output and temperature behavior.

A larger alternator is applied for a lower temperature rise with increased copper resulting in lower current density. Increased size and copper permits higher motor starting kVA and lower voltage dips on application of the load. It also means reduced voltage distortion and overheating, due to harmonics induced by non-linear loads

The temperature class of the insulation system is typically determined using the test methods outlined in Underwriters Laboratory standard UL 1446 (Systems of Insulating Materials – General)

8.0 Checking Deterioration of Winding Insulation:

Winding insulation should be checked if the generator has been subjected to any of the following:

- Been stationary for a long period without anti-condensation heaters turned on
- Been subject to an intake of high volumes of water
- Windings are contaminated with airborne dust and dirt, or may have become damp due to high humidity
- Windings are contaminated with airborne corrosive elements such as salt or corrosive chemicals in the atmosphere

MEMBER EGSA Electrical Generating Systems Association

Corporate Office
2211 American Blvd.
DePere, WI 54115
(920) 964-1400
(888) 548-1400
(920) 964-1409 (fax)

Milwaukee
8525 N. 87th St.
Milwaukee, WI 53224
(414) 357-7900
(800) 236-6626
(414) 357-6278 (fax)

Minneapolis
14950 Martin Drive
Eden Prairie, MN 54344
(651) 925-3183
(866) 583-1671
(651) 925-3184 (fax)

Grand Rapids
4324 Airlane Dr. SE
Grand Rapids, MI 49512
(616) 971-0141
(888) 341-5610
(616) 971-0146 (fax)

Total Energy Systems, LLC
www.totalenergysystems.com