Hazardous Locations

Contents:

Notes:

1. The following information is based on NFPA-70, the **National Electrical Code** and on U.L.-674, **Classified Electric Motors and Generators for use in Division 1 Hazardous Locations, Class I, Group C and D, Class II, Groups E, F and G** and applies to areas where this Code has been adopted and U. L. is an accepted Organization for Listing/Labeling services. Other areas, especially those outside the U.S.A., may have adopted Codes and/or standards that are similar but not identical in definitions and requirements.
2. The following information can be considered a guide to NEC/U.L. Hazardous Location Motor requirements, but not an official interpretation.

I. Organizations, Standards and Basic Definitions

The National Electrical Code (NEC) is a document which sets forth minimum standard requirements for electrical installations and equipment. The code is published by the National Fire Protection Association NFPA in order to promulgate electrical safety and has been adopted by most state and local inspection authorities as the basis for requirements in electrical installations in the U.S.A.

Underwriters Laboratories (U.L.) is an independent testing organization which develops construction and performance standards for, and tests, electrical equipment in accordance with the requirements set forth in the NEC. U.L. also provides a combination product Listing and Labeling service for equipment they have tested and approved.

Listed and/or Labeled products are products for which an organization, acceptable to the authorities having jurisdiction, provides a periodic production inspection. The Listed product appears on a list published by the organization, indicating appropriate standards and/or testing have been met. The Labeled product has and identifying mark of the organization and is the manufacturer's indication that appropriate standards or performance have been met. U.L. stipulates that their Listing only applies to products that are additionally U.L. Labeled.

> **Approved:** Acceptable to the authority having jurisdiction. (The authority having jurisdiction may be the government, insurer and/or property owner, or their designed representative).
>
> **Summary:** Property owner, insurer, or government agency, etc. (Authority having jurisdiction) adopts certain guidelines (e.g., NEC) for installations he/she/it is responsible for.

Where testing or evaluation of equipment is required, he/she/it can accept (approve) equipment identified (Listed or Labeled) as being tested/evaluated by and organization (such as U.L.) that he trusts (acceptable), and that provides follow-up inspections at the location of manufacture.

II. NEC Hazardous Location Classification and Ignition Temperatures

A Hazardous Location is an area where a fire and/or explosion hazard may exist due to flammable gasses or vapors, flammable liquids, combustible dust, or ignitable fibers or flyings. The area is classified in accordance with properties of the material responsible for the potential hazard and with the likelihood of the hazard actually being present.

The following explains the significance of Class, Group, Division and Ignition Temperature.

Class is used to provide a general definition of the physical characteristics of the hazardous material with which we are dealing. The three classes are:

> **Class I**
> Gasses, vapors and liquids that can be present in explosive or ignitable mixtures. For example: Gasoline - As a vapor (or liquid) is ignitable and/or explosive; therefore, it is a Class I material.
>
> **Class II**
> Dust, Combustible dust that can be present in amounts that could produce potentially explosive mixtures, or dust of an electrically conductive nature.
>
> Examples: Flour or cornstarch. As a compact mass these products may only burn or smolder but when finely distributed in air. The mixture becomes explosive.
>
> Metallic dust such as aluminum or magnesium have several dangerous properties.
>
> A. They are electrically conductive.
> B. They can burn very violently even when not finely distributed in air.
> C. When finely distributed in air they can be violently explosive.

All fall into Class II - Dust.

Class III - Fibers or flyings that are easily ignitable but are not apt to be suspended in air in such amounts to produce ignitable mixtures.

Example: Rayon, Nylon, Cotton, Sawdust or Wood Chips, etc.

Group designations are used to selectively group the material by relatively similar hazardous characteristics.

For Example: Both gasoline and hydrogen are explosive when mixed with and ignited, but the explosive effect and violence of the resulting explosion will be substantially different.

Groups are designed by the letters A through G. A through D are Groups for Class I and E through G are Groups for Class II.

A, B, C, D - Gases/vapors are grouped by:

- Severity of explosion pressure expected.
- Extent of flame propagation between parts.

E, F, G, - Dusts are grouped by:

- Combustibility
- Penetrability between parts
- Ability to contribute to creation of an ignition source (abrasiveness, electrical conductiveness).
- Blanketing effect
- Ignition temperatures

Classification of Gases, Vapors and Dusts for Electrical Equipment

(NFPA-497M) can be used by authorities having jurisdiction as a guide for determining the Class and Group of a particular material. It includes materials classified by test and materials classified by analogy to tested materials. Authorities should consider verifying classifications by test if the material of concern has only been classified by analogy.

Division

Divisions are used to evaluate the possibility of the hazardous material being present at a particular location in ignitable mixtures. Two Division classifications are utilized, Division 1 and Division 2.

Ignition Temperature

In addition to having physical properties that make them different from each other (Class) and different explosive characteristics once they are ignited (Group), hazardous substances also have one other characteristic that must be dealt with. This characteristic is the ignition temperature. The minimum ignition temperature is the minimum temperature at which the substance will start to burn or explode.

Example: Virtually every car is equipped with and electric cigarette lighter. Obviously this lighter

will not light a cigarette when the lighter is *cold.* Similarly when it is heated to the point where the element glows, it will light a cigarette. At some point in the range between cold and glowing hot, there is a temperature where it would not light the cigarette, but an increase of only one degree would make it hot enough to ignite the tobacco. The temperature at which ignition is possible would be the *ignition temperature* of the cigarette.

Materials can have the same physical properties (Class) and similar explosive properties (Group), but substantially different ignition temperatures. There is no consistent relationship between explosion properties and ignition temperature.

For example: A common Class I, Group D solvent, acetone, has an approximate ignition temperature of 465°C. Gasoline, also Class I, Group D, has an approximate ignition temperature of 280°C. Therefore, Class I, Group D equipment with a maximum surface temperature at 350°C could be used in an acetone environment, but the same equipment operated in gasoline vapors could cause ignition or explosion due to the 280°C ignition temperature of gasoline.

Some Group C gasses have higher ignition temperature than certain Group D gasses, and some have lower. The same can be said for any two Groups.

Ignition Temperature Determination

Due to effects of various conditions on ignition temperatures, we cannot assume responsibility for determining the required ignition temperature.

Fire Hazard Properties of Flammable Liquids, Gasses and Volatile Solids (NFPA-325M) can be used as a guide, but in that it is not a standard and that it qualifies itself with the fact that ignition temperatures can vary with conditions, and therefore, "ignition temperatures should be looked upon only as approximations", user and authorities having jurisdiction must bear the responsibility for ignition temperature determination.

Summary

- Class: Denotes physical characteristics of the materials.
- Group: Categorizes the materials by relatively similar hazardous characteristics.
- Division: Classifies the likelihood of the presence of the hazardous condition.
- Ignition Temperature: Temperature at which material will ignite (independent of GROUP classification).

III. Ignition Temperature vs. Temperature Markings

In general, the NEC stipulates that an operating temperature or temperature range marking appears on equipment approved for Division 1 Hazardous Locations. For motors, U.L. further clarifies that this marking is to indicate the maximum temperature for all conditions including overload, locked rotor and single-phasing.

Per the NEC, the temperature range marking is in the form of an Identification Number shown in the below. U.L. calls this a Code Number.

T-Codes and Associated Temperature
Identification Numbers Maximum Temperature

T1	450°C	842°C
T2	300	572
T2A	280	536
T2B	260	500
T2C	230	446
T2D	215	419
T3	200	392
T3A	180	356
T3B	165	329
T3C	160	320
T4	135	275
T4A	120	248
T5	100	212
T6	85	185

The user should make sure the temperature marking on approved equipment does not designate a temperature greater than the ignition temperature of the hazardous dust, fiber, gas or vapor of concern, even if the marked Class and Group meet the location requirements.

IV. Motors for NEC Division 1 Hazardous Locations

The following describes what goes into producing motors for Division 1 Hazardous Locations.

Approval:
Equipment must be approved for use in Hazardous Locations by authorities having jurisdiction. In the case of Division 1, practice necessities use of Underwriters Laboratories Inc., Labeled motors (see footnote under "ORGANIZATIONS AND STANDARDS AND BASIC DEFINITIONS").

Class I and Class II U.L. Labeled motors are U.L. Listed in accordance with design criteria and testing established and conducted by U.L. with respect to the NEC definitions of Explosionproof (Class I) and dust-ignition-proof (Class II).

Explosionproof Apparatus:

1. Enclosure capable of:

   a. Withstanding an explosion of a specified gas/vapor, occurring within, and of
   b. preventing ignition of specified surrounding gas/vapor by sparks, flashes, or explosion of gas/vapor within,

2. Operates at an external temperature that will not ignite surrounding flammable atmosphere.

Dust Ignition-proof:

1. Enclosure will exclude amounts of dust that can either ignite, or affect performance or rating -

2. where installed and protected per the NEC, will not permit arcs, sparks, or heat otherwise generated or liberated from within to cause ignition of a specific dust that is:

a. accumulated on the enclosure, or
b. suspended in the atmosphere in the vicinity of enclosure.

Design and Testing Considerations

1. Dimensional tolerances (specifics depend on location classification).

a. Open path around shaft vs. flame propagation properties of gas/vapor, or ability of dust to penetrate.
b. Joints between parts vs. flame propagation properties of gas/vapor, or ability of dust to penetrate.
c. Thickness' and strength of enclosure, especially with respect to gas/vapor explosion pressures.

"Strength" is defined by U.L. "The ability of a motor enclosure to withstand internal explosion pressures". This investigation can be carried out in either of two different ways:

1) "by calculations" or

2) "by hydrostatic pressure tests"

When the strength is evaluated "by calculations", U.L. uses equations based on literature on strength of materials, such as given in **Machinery's Handbook**, and information obtained by U.L. in conducting strength tests on Hazardous Location devices. Calculations can only be used if the part shape sufficiently conforms to shapes the strength of materials equations are based on.

In both cases ("by calculations" and "by hydrostatic tests") an explosion pressure is established by explosion testing. This testing is done on representative sample motors with a gas- or vapor-air mixture that is representative of the Group classification to be marked or Labeled on the motors. The explosion pressure is multiplied by a safety factor that depends on type of material, part and method of strength evaluation (by calculation or by hydrostatic pressure). The calculations and/or hydrostatic tests are then carried out using the safety factored explosion pressure valve.

2. Material description - including type and properties.

e.g. Ability of fans to spark due to being struck and/or ability of fans and fan guards to spark due to static electricity.

3. Surface temperature:

In free-open air, for Class I (gasses/vapors). Under various conditions of dust cover and atmosphere suspension for Class II. Not to exceed levels in following chart:

Maximum Surface Temperatures on U.L.

Labeled, Hazardous Location Motors

	F.L. Operating Conditions	Under All Operating Conditions (A)
Class I		
Group D		215°C (B)

Group C		160°C (C)
Class II		
Group E	200°C	200°C
Group F	150°C (E)	200°C
Group G	120°C (E)	165°C (D)

(A) Includes overload, single phasing and locked rotor.

(B) May exceed 215°C if it does not exceed 280°C, but needs a caution plate.

(C) May exceed 160°C if it does not exceed 180°C, but needs a caution plate.

(D) When packed with moist dust, baked on.

(E) Under a dry dust cover.

Marking:
U.L. Hazardous Location Labeled motors, in accordance with the **NEC**, must be marked with the Class, Group and Surface Temperature established with the previously described DESIGN AND TESTING CONSIDERATIONS. The motor is then intended for use in atmospheres containing those materials indicated by the marked Class and Group as long as the ignition temperature of the material is not less than indicated by the surface temperature marking.

The Surface Temperature mark can be in the form of an Operating Temperature Code, as described in **III. Ignition Temperature vs. Temperature Markings'.**

When thermostats are used to limit surface temperature, U.L. requires that certain connection instructions are to be provided.

V. U.S. MOTORS® brand motors for NEC Division 1 Hazardous Locations

The Class, Group and Temperature Code available on motors depends on the frame, type and rating, and will generally be one of the following:

- Class I Group D, T2B (265°C)
- Class I Group D, Class II Groups F, G, E,F, and G. T3B (165°C)
- Class I Groups C and D, Class II Groups F and G, T3C (160°C)

Mechanical Design Differences:

a. **Group C motors** have an extended labyrinth inner shaft path and stronger enclosure requirements over Group D motors. The extended labyrinth shaft path usually involves the bearing cap and shaft configurations. The stronger enclosure requirement results in tensile strength and thickness considerations.

b. **Class II Group E** is also available on some frames as a special modification to designs listed for Class II Groups F and G. A special bushing or slinger is needed at both ends of shaft to impede

Group E dust penetration.

Temperature Codes:
T2B corresponds with 260°C maximum, and sometimes requires winding thermostats

T3B and T3C correspond to 165°C and 160°C maximum respectively and will always require winding thermostats.

Thermostats: Where the design requires winding thermostats for surface temperature limitation, a magnetic starter with a 3-wire pilot circuit and utilizing a manual momentary start switch must be used for the motor power connection and the thermostats (which are themselves internally connected in series) must be connected in series with the starter holding coil (stop button). The thermostat leads are marked either "P", or "P1" and "P2". The motor controller circuit must be compatible with the thermostat rating at times necessitating the motor to controller connection to be via a transformer (such as would be the case with motors rated above 600 volts). Solid state switching is not permissible for shut-off or start-up due to potentially undesirable effects of transients.

If one or more of these thermostats opens due to over temperature, the motor stops and cannot restart or be restarted until the motor temperature has cooled down and the thermostat resets. Resetting of the internal thermostat is automatic, but the motor will still not restart until after the start switch is depressed.

The following motors are supplied with thermostats which must be connected:

a. Any Hazardous Location motor Frame 5000 through 5800.

1. Any motor with Class I Group C or Class II included on the Label and *some products that are Labeled for just Class I* Group D T2B.

2. Any motor made by us having a T-Code on the Label for a temperature lower than 260°C (T2B).

VI. Nameplates and Labels for U.L. Listed Hazardous Location Motors

All motors having Underwriters Laboratories Listing for Hazardous Locations carry a Label similar to the shown in Figure 1, indicating the Class(es) division 1 or 2 and Group(s) of the Location(s) the motor is intended for, as well as the maximum Operating Temperature of the motor's external surface. (See HAZARDOUS LOCATION CLASSIFICATION, and IGNITION TEMPERATURE VS. TEMPERATURE MARKINGS).

FIGURE 1

Thermostat Connection Diagram:

Motors requiring connection of internal thermostats to limit the surface temperature to that indicated by the marked Operating Temperature Code should have an additional Connection Diagram Label similar to Figure 2.

The motor controller circuit must be compatible with the thermostat rating, at times necessitating the motor to controller connection to be via a transformer (such as would be the case with a motor rated for above volts). Refer to "THERMOSTATS" under **"SECTION V."** for details.

FIGURE 2

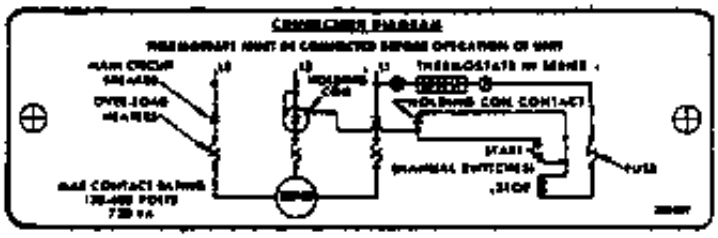
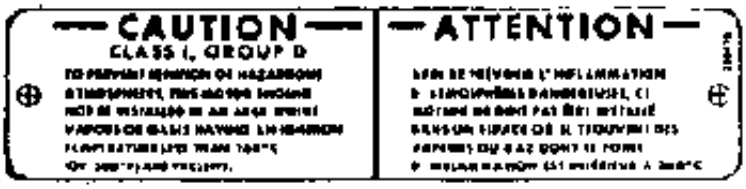


FIGURE 3



Temperature Caution Label:

Motors may also have a Caution label similar to the one above. In general, for a given Class and Group, U.L. specifies an upper limit to the maximum Operating Temperature allowed. These limits are 160°C for Group C, 215°C for Group D, 200°C for Groups E and F, and 165°C for Group G. As an exception to this rule, if a label similar to Figure 3 is provided (substituting the actual "Group" and the ignition temperature corresponding to the actual motor Operating Temperature marking, U.L. will allow maximum Operating Temperatures higher than 160°C up to 180°C for Group C and higher than 215°C up to 280°C for Group D. Note that no motor should be installed in an area where vapors, gases, liquids, dusts, fibers or flyings are present having an ignition temperature less than that indicated by the Temperature Code Labeled on the motor, regardless of whether this caution label is used or not.

This plate is only provided on motor class D GR. D with out thermostat. Also, the plate is no longer rescued by U.L. - however still used by U.L.

VII. Motors & NEC Division 2 Locations

The following provides information on motor application in Division 2 environments. In accordance with NEMA's Safety Standard MC2-3.05, our recommendation is to supply a motor approved for Division 1.

In any case, suitability of a motor for use in a Division 2 area is the responsibility of the user and authorities having jurisdiction. This is especially important to note when customers ask for motor in a General Purpose Enclosure as defined below.

General Purpose Enclosure:
For the subject of Hazardous Locations, "General Purpose Enclosure" means any enclosure that is not U.L. Labeled with the Class, Group or Operating Temperature Code called for by the hazardous material in question

(not to be confused with the NEMA definitions for "General Purpose" motors).

NEC Requirements for Equipment with General Purpose Enclosures:
In article 500-2(1), the NEC states that exposed surfaces shall not operate at temperatures higher than the ignition temperature of the specific gas/vapor, dust, or fiber/flyings, and that where a General Purpose Enclosure is allowed, the equipment cannot constitute a source of ignition under normal operating conditions.

Equipment can be a source of ignition when sparks or arcs having enough energy are produced or when exposed surface temperatures are greater than the ignition temperature of the material in question.

For Class I (gases/vapors), internal and external, temperatures (NEC-1984 501-8(b)) and sparking/arcing, have to be considered by the user because the General Purpose Enclosure will not contain explosions of flames, etc., resulting from internal ignitions. For Class II and III (dusts and fibers), internal temperatures and sparking/arcing conditions must be considered in addition to external temperature (which have to be considered in any case) where the enclosure does not suitably impede entrance of the material in question, or impede exit of sparks/arcs.

VIII. Rules for Handling Orders and Inquires

A. Division I

Customer should providing Class, Group and Operating Temperature requirements.

We cannot assume responsibility for Class, Group and Operating Temperature determination. Ultimate responsibility is in the hands of user and authorities having jurisdiction.

Note and example:

> Our standard "Single Label" Class I Group D motors have a T2B (260°C) Operating Temperature Code. There are Class I Group D gasses having ignition temperatures lower than 260°C which out T2B motor, therefore, could not be use in (i.e. It cannot be used in presence of a Class I Group D gas having a 215°C ignition temperature).

B. Division 2

Our official recommendation is that user use motor U.L. Labeled for Class, Group and Operating Temperature for his application. The probability of a motor causing an explosion is greater for the motor not Labeled for the appropriate Class, Group and Operating Temperature, than for the motor that is appropriately Labeled, regardless of the manufacturer.

Suitability for use in a Division 2 Location, of a motor not U.L. Labeled with the Class, Group, or Operating Temperature dictated by the hazardous material in question, is the responsibility of the user and authorities having jurisdiction.

Refer to the office if motor to be supplied or quoted cannot be appropriately U.L. Labeled.

IX. Variable and\or Non-Sinusoidal Frequency Inputs, Including Inverters}

A. Listing:

The U.L. Listing/Label of a Hazardous Location Motor applied to rated nameplate frequency and assumes sinusoidal unless otherwise specified. The same applied to non-sinusoidal inputs when the motor is not marked for non-sinusoidal inputs.

The thermal current, and other affects should be taken into consideration when applying power inputs other than for which the motor is marked for.

B. Temperature, Current and Other

1. Variable frequency affects these features.
2. Non-Sinusoidal (Inverters).

Harmonics involved with non-sinusoidal inputs affect these features, even if the non-sinusoidal frequency is the same as the sinusoidal frequency.

C. U.S. MOTORS® brand offering 56 through 326T frame contract DH and variable torque class I GR D and\or GR C and D - class II GR's frame - and\or E, F and G. Temperature code either T and B or T and C.

Conclusion\summary
Decision as to the suitability of a motor for use with variable and/or non-sinusoidal frequency inputs, in a Hazardous Location, is the responsibility of the use and authorities having jurisdiction over the installation where the motor is not marked for the frequency variation and/or the non-sinusoidal input to be used.

The user and authorities making the decision as to suitability should consult the motor manufacturer for information concerning expected motor characteristics.

Information concerning our products should be obtained from customer service through the office.

X. Rebuilt Motor Shops/Rework on Labeled Motors
Problem: A motor Labeled for Hazardous Locations needs to be serviced with some confidence that the integrity of the original Listing is maintained, but it would take too long to ship it back to the plant of manufacture.

Solution: U.L. Lists service repair shops around the country to do work on U.L. Labeled Hazardous Location motors. The category for this Hazardous Location Listing is called "MOTOR AND GENERATORS, REBUILT". Each motor worked on receives a new U.L. Label which includes the marking:

Underwriters Laboratories Inc. Listed Rebuilt Electrical Motor for Hazardous Locations

The LISTING/LABELING procedure applies to the service shop as it would with a production facility.

Limitations:

A) Conversion work for original sales. If a salesperson wants to have a motor converted for original sale, he/she should note the resultant motor will be marked "REBUILT" which might not be acceptable to a customer looking

for a NEW motor.

B) The type of work a REBUILT MOTOR shop can do under their U.L. Listing is generally limited to the types of work that can be done to any manufacturer's motor, without potentially violating the confidentiality of the manufacturer's design information. Where such confidential information is involved, special coordination is required between the service shop, the manufacturer, and U.L., even where the service shop is affiliated with or owned by the manufacturer.

1. The service shop must submit to U.L. for a Procedure revision.
2. The manufacturer must give U.L. permission to transfer file information from the manufacturer's file to the service shop file.
3. The service shop pays U.L. a charge for the file transfer.