

Electrical Classification

Using NFPA 70 and NFPA 499 to Classify Hazardous Locations

Electrical classifications are established in accordance with the National Electrical Code, NFPA 70, also referred to as the NEC. The NEC requires that the hazardous areas in a facility be documented in a form that ensures that repairs, revisions and designs of electrical systems are executed in conformance with the area classification. Section 500.4 states:

“Documentation. *All areas designated as hazardous (classified) locations shall be properly documented. This documentation shall be available to those authorized to design, install, inspect, maintain, or operate electrical equipment at the location.”*

This requirement is usually satisfied by developing a site plan that has the hazardous areas shown along with the classification of those hazardous areas. If such a plan is lacking, there is a high probability that electrical equipment that is NOT appropriate for a particular hazardous location will be installed as the facility is maintained and revised on a going-forward basis. This could lead to an ignition of a hazardous atmosphere by electrical equipment that was inappropriate for the location yet installed in ignorance of the need for “classified” electrical equipment in the area where the hazardous atmosphere occurred.

Section 500.5 continues:

“Classifications of Locations. *Locations shall be classified depending on the properties of the flammable vapors, liquids, or gases, or combustible dusts or fibers that may be present, and the likelihood that a flammable or combustible concentration or quantity is present. Where pyrophoric materials are the only materials used or handled, these locations shall not be classified. Each room, section, or area shall be considered individually in determining its classification.*

FPN: *Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required.”*

This language obligates the facility owner/operator to undertake the process of reviewing the facility for the conditions that establish the need for electrical classification, i.e. areas containing flammable gases, flammable vapors or combustible dusts. In this article locations containing combustible dusts are defined as “Class II” hazardous locations.

Class II hazardous locations are divided into two divisions, Division 1 and Division 2, based upon the relative probability of the occurrence of an ignitable dust cloud concurrent with an electrical ignition source. Section 500 of the NEC also classifies dusts in groups. Group E dusts are electrically conductive, metallic dusts. Group F dusts are carbonaceous dusts such as carbon black, graphite, etc. Group G dusts are

other organic dusts such as cellulose, plastics, starches, polymers, etc. Sugar dust would be deemed a Group G particulate.

Section 500.5 defines a Class II, Division 1 hazardous location as:

“...a location

(1) In which combustible dust is in the air under normal operating conditions in quantities sufficient to produce explosive or ignitable mixtures, or

(2) Where mechanical failure or abnormal operation of machinery or equipment might cause such explosive or ignitable mixtures to be produced, and might also provide a source of ignition through simultaneous failure of electric equipment, through operation of protection devices, or from other causes, or

(3) In which Group E combustible dusts may be present in quantities sufficient to be hazardous.

FPN: Dusts containing magnesium or aluminum are particularly hazardous, and the use of extreme precaution is necessary to avoid ignition and explosion.”

This language leaves considerable latitude for the interpretation of the facility designer or the AHJ. To assist users in applying these criteria NFPA publishes NFPA 499, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, 2004 Edition. This recommended practice provides more concrete guidance on how to interpret the criteria in the NEC. NFPA 499 states:

“5.2.1 Where a dust cloud is likely to be present under normal conditions, the location should be classified as Division 1.

5.2.2 Where a dust layer greater than 1/8th in. (3.0 mm) thick is present under normal conditions, the location should be classified as Division 1.*

5.2.3 “Normal” does not necessarily mean the situation that prevails when everything is working properly.

5.2.3.1 For instance, if a bucket elevator requires frequent maintenance and repair, this repair should be viewed as normal.

5.2.3.2 If quantities of ignitable dust are released as a result of the maintenance, the location is Division 1.

5.2.3.3 However, if that elevator is replaced and now repairs are not usually required between turnarounds, the need for repairs is considered abnormal.

5.2.3.4 The classification of the location, therefore, is related to equipment maintenance, both procedures and frequencies.

5.2.3.5 Similarly, if the problem is the buildup of dust layers without the presence of visible dust suspensions, good and frequent cleaning procedures or the lack thereof will influence the classification of the location.”

This language provides a clear metric for the determination of an area as a Class II, Division 1 hazardous location. While the language of the NEC allows the use of other criteria if a hazard and risk analysis supports it, the criteria in NFPA 499 are used as the presumptive criteria when other engineered criteria have not been developed. Consequently, a Class II, Division 1 designation is appropriate where:

- A visible dust cloud is present in the air under normal operating conditions,
- A dust layer in excess of 1/8th of an inch in depth is present at some time between cleaning episodes.

Adjacent to the Class II, Division 1 hazardous location is an area that is inherently less hazardous because the concentration of the dust cloud is lower or because the thickness of the dust layer is less (unless the Division 1 location is entirely enclosed within walls). The reduced quantity of dust in the area makes it less likely that a dust cloud having a concentration sufficiently high to be capable of propagating a deflagration could occur in that area.

Section 500.5 defines a Class II, Division 2 hazardous location as:

“... a location

(1) In which combustible dust due to abnormal operations may be present in the air in quantities sufficient to produce explosive or ignitable mixtures; or

(2) Where combustible dust accumulations are present but are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but could as a result of infrequent malfunctioning of handling or processing equipment become suspended in the air; or

(3) In which combustible dust accumulations on, in, or in the vicinity of the electrical equipment could be sufficient to interfere with the safe dissipation of heat from electrical equipment, or could be ignitable by abnormal operation or failure of electrical equipment.

FPN No. 1: The quantity of combustible dust that may be present and the adequacy of dust removal systems are factors that merit consideration in determining the classification and may result in an unclassified area.

FPN No. 2: Where products such as seed are handled in a manner that produces low quantities of dust, the amount of dust deposited may not warrant classification.

Again, this language leaves considerable latitude for the interpretation of the facility designer or the AHJ. To assist users in applying these criteria we return to NFPA 499. NFPA 499 states:

5.3.1 *The criterion for a Division 2 location is whether the location is likely to have ignitable dust suspensions or hazardous dust accumulations only under abnormal conditions. The term “abnormal” is used here in a limited sense and does not include a major catastrophe.*

5.3.2 *As an example, consider the replaced bucket elevator of 5.2.3.2, which releases ignitable dust only under abnormal conditions. In this case there is no Division 1 location because the elevator is normally tight. To release dust, the elevator would have to leak, and that would not be normal.*

5.3.3 *Chemical process equipment does not fail often. Furthermore, the electrical installation requirement of the NEC for Division 2 locations is such that an ignition-capable spark or hot surface will occur only in the event of abnormal operation or failure of electrical equipment. Otherwise, sparks and hot surfaces are not present or are contained in enclosures. On a realistic basis, the possibility of process equipment and electrical equipment failing simultaneously is remote.*

5.3.4 *The Division 2 classification is applicable to conditions not involving equipment failure. For example, consider a location classified as Division 1 because of normal presence of ignitable dust suspension. Obviously, one side of the Division 1 boundary cannot be normally hazardous and the opposite side never hazardous. Similarly, consider a location classified as Division 1 because of the normal presence of hazardous dust accumulations. One side of the division boundary cannot be normally hazardous, with thick layers of dust, and the other side unclassified, with no dust, unless there is an intervening wall.*

5.3.5 *When there is no wall, a surrounding transition Division 2 location separates a Division 1 location from an unclassified location.*

5.3.6 *Walls are much more important in separating Division 1 locations from Division 2 and unclassified locations in Class II locations than in Class I locations.*

5.3.6.1 *Only unpierced solid walls make satisfactory barriers in Class I locations, whereas closed doors, lightweight partitions, or even partial partitions could make satisfactory walls between Class II, Division 1 locations and unclassified locations.*

5.3.6.2 *Area classification does not extend beyond the wall, provided it is effective in preventing the passage of dust in suspension or layer form.*

From the guidance in NFPA 499 we can conclude that Class II, Division 2 hazardous locations are areas where:

- There are no visible dust clouds under normal operating conditions such as operating, routine maintenance or commonly occurring production upsets and
- There are no dust layers exceeding 1/8th of an inch in depth.

However dust layers less than 1/8th of an inch are permissible in a Class II, Division 2 location. This is underscored in the diagrams for the designation of hazardous locations

in Section 5.8 of NFPA 499. These diagrams make reference to dust layers that are sufficiently thick to change the perceived color of equipment but less than 1/8th inch in depth as being illustrative of the dust layers that would be acceptable in a Class II, Division 2 hazardous location.

It is important to keep in mind that where ever dust layers are occurring, because the dust does not dissipate as do gases, Division 2 locations can become Division 1 locations if they are not cleaned. Likewise, Division 1 locations can some times be reclassified as Division 2 if the cleaning program is sufficient to prevent the dust layers from attaining the 1/8th inch thickness criterion as long as there are no visible dust clouds present under “normal” operating conditions.

NFPA 499 also addresses how to recognize areas that are not generally deemed to require classification. These are “unclassified locations. Section 5.4.1 of NFPA 499 states:

“5.4.1. Experience has shown that the release of ignitable dust suspensions from some operations and apparatus is so infrequent that area classification is not necessary. For example, where combustible dusts are processed, stored, or handled, it is usually not necessary to classify the following locations:

- (1) Where materials are stored in sealed containers (e.g., bags, drums, or fiber packs on pallets or racks)*
- (2) Where materials are transported in well-maintained closed piping systems*
- (3) Where palletized materials with minimal dust are handled or used*
- (4) Where closed tanks are used for storage and handling*
- (5) Where dust removal systems prevent the following:*
 - (a) Visual dust clouds*
 - (b) Layer accumulations that make surface colors indiscernible (see A.5.2.2)*
- (6) Where excellent housekeeping prevents the following:*
 - (a) Visual dust clouds*
 - (b) Layer accumulations that make surface colors indiscernible (see A.5.2.2)*

5.4.2 Dust removal systems that are provided to allow an unclassified location should have adequate safeguards and warnings against failure.

Areas that do not have discernable accumulated fugitive dust layers are not required to be classified.

Using the Classification Diagrams of NFPA 499

The classification of a facility is executed in conformance with the classification diagrams in Section 5.8 of NFPA 499. These diagrams envision an identified source of dust leakage. It is important to note that these classification diagrams are based upon an assumption that the particulate has a bulk density of 40 pounds per cubic foot. Section 5.6.4 states:

5.6.4 These diagrams apply to operating equipment processing dusts when the specific particle density is greater than 40 lb/ft³ (640.72 kg/m³). When dusts with a specific particle density less than 40 lb/ft³ (640.72 kg/m³) are being handled, there is a pronounced tendency for the fine dust to drift on air currents normally present in industrial plants for distances considerably farther than those shown on these diagrams. In those cases it will be necessary to extend the hazardous (classified) location using sound engineering judgment and experience.

Bulk density is not the same as specific particle density. Bulk density is always lower than specific particle density as it includes the air between the particles. As the particles get smaller the bulk density approaches the specific particle density. The classification diagrams establish the absolute minimum dimensions of the classified area.

The Class II, Division 1 hazardous location extends from the source of dust leakage for a radius of 20 feet in all directions. Consequently, where the floor to ceiling height is less than 20 feet, the Class II, Division 1 hazardous location extends from floor to ceiling in the locus of the source of dust emission and for a radius of 20 feet around the source. This is illustrated in Figure 5.8(a) of NFPA 499. If the area having a dust layer depth greater than 1/8th extends more than 20 feet from the dust emission source the Class II, Division 1 area must be extended to encompass the entire area having dust layers equal or greater than 1/8th inch in depth.

The Class II, Division 1 area is surrounded by an area designated as Class II, Division 2. This is the area where the accumulated fugitive dust layer is less than 1/8th inch but sufficient to change the perceived color of the surfaces upon which it has accumulated. The Class II, Division 2 hazardous area extends at least 10 feet beyond the boundary of the Class II, Division 1 area. This is shown in Figure 5.8(a) of NFPA 499.

Where the rate of leakage is sufficiently low that the regular cleaning program is able to keep the thickness of the accumulated fugitive dust layer to less than 1/8th of an inch there is no Class II, Division 1 hazardous location. The entire area around the fugitive dust source is classified as a Class II, Division 2 location for a radius of at least 10 feet about the fugitive dust source. This is shown in Figure 5.8(c). If the dust layer extends beyond the 10 foot radius, the area of the Class II, Division 2 designation must be extended to encompass the entire area where there are discernable dust layers on equipment upward-facing surfaces. In some cases the fugitive dust emission source or sources are encompassed within a room. The room walls can confine dust accumulations resulting in the entire room requiring classification as a Class II, Division 2 hazardous location which includes one or more Class II, Division 1 areas that extend out from the source a distance of 20 feet. This is shown in Figure 5.8(h). Where there are multiple sources of fugitive dust emissions within a building compartment, room or

area subdivision it can be necessary to classify the entire compartment based upon layer depth. This is shown in Figure 5.8 (f) and 5.8 (i) in NFPA 499.

There are situations where the equipment handling the particulate is tight and there is no discernable evidence of fugitive dust emission. These can include compartments where pneumatic conveying ducts pass, the process is totally enclosed or where the fugitive dust management by a dust collection system is sufficient to prevent fugitive emissions beyond the pick-ups. In these cases there is no basis to require classification of the area as hazardous. This is shown in Figure 5.8 (d). Thus there is no basis to require classification in areas where combustible particulate solids are stored in bags, super-sacks, tanks and bins as long as there are no dust clouds or layer accumulations also in the area. This eliminates the need to consider warehouse areas for classification. Furthermore, if there is a fugitive dust management system in place that is operating in such a manner that there are neither visible dust clouds nor dust accumulations sufficiently thick to affect the perceived color of equipment surfaces then the area can be designated “unclassified”. If a dust management system is NOT in place but there is an aggressive housekeeping program that prevents the accumulation of discernable dust layers on equipment there is a basis for not classifying the area. However, as soon as there is an interruption in the housekeeping program and dust begins to accumulate the requirement for classification is triggered and equipment suitable for the hazardous location must be employed.

Classifying Hazardous Locations

The process of classifying hazardous locations is critical to the safe operation of facilities that handle combustible particulate solids. The need to perform a classification review is triggered when ever combustible particulate solids are handled.ⁱ

Generally classification is performed by a licensed professional engineer who has demonstrated the core competencies in the discipline of Fire Protection Engineering. While classification of hazardous areas relates to electrical service there is little, if any, electrical engineering involved. Instead there is heavy reliance upon the recognition and assessment of fire/explosion hazards and the risks those hazards represent. This necessitates that the engineer have a solid understanding of the chemical nature of the particulates, the physical characteristics of the particulates, the process equipment, process operations, the building structure housing the process equipment and the history of incidents in similar processes.

Applying the Classification Requirements

The National Electrical Code (NEC or NFPA 70) requires that:

“Locations shall be classified depending on the properties of the flammable vapors, liquids, or gases, or combustible dusts or fibers that may be present, and the likelihood that a flammable or combustible concentration or quantity is present. Where pyrophoric materials are the only materials used or handled, these locations shall not be classified. Each room, section, or area shall be considered individually in determining its classification.”

FPN: Through the exercise of ingenuity in the layout of electrical installations for hazardous (classified) locations, it is frequently possible to locate much of the equipment in a reduced level of classification or in an unclassified location and, thus, to reduce the amount of special equipment required.”

This is a mandatory requirement. Furthermore the NEC states also that:

This Code is not intended as a design specification or an instruction manual for untrained persons.”ⁱⁱ

Thus the NEC is intended to be used by those persons who have been trained in its proper use. These two sections taken together establishes a requirement that a qualified person review each facility to determine the extent to which the space should be classified for electrical service consisting of components that have been Listed as being suitable for hazardous locations.

ⁱ Section 5.7.1, NFPA 499, Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas, 2004 Edition, National Fire Protection Association, Quincy, MA, 02269, 2004.

ⁱⁱ Section 90.1(c), NFPA 70-2005, National Electrical Code, 2005 Edition, National Fire Protection Association, Quincy, MA 02269, 2005.