

# Determining the proper hazardous area classification

Here's a common-sense approach using a basic four-part process

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The concept of assessing and limiting the risk associated with installing electrical devices in areas where potentially explosive atmospheres may be present is referred to as area classification. Hazardous area classification assessment is a probability analysis and risk assessment evaluation of a manufacturing or process area processing a potentially flammable atmosphere that focuses exclusively on minimizing or eliminating electrical energy as a potential ignition source. Hazardous area classification is not intended to be a secondary line of defense against poor process design, poor facility and equipment maintenance, faulty equipment operation, or catastrophic vapor releases. Hazardous areas are divided into three distinct classes that totally depend on the material type that is encountered in the process.

**Class I areas.** These are locations where flammable gases or vapors are or may be present in the air in quantities sufficient to produce an explosive or ignitable mixture. In Class I areas that utilize the division concept methodology, two distinct divisions are predicated on the operational interpretation of normal vs. abnormal and frequent vs. infrequent.

Division 1 locations where ignitable concentrations of flammable gases or vapors can exist are due to:

- Under normal operating conditions
- Frequently because of maintenance or repair
- Frequent leakage
- Below grade where adequate ventilation does not exist
- When releases from faulty process equipment operations result in the simultaneous failure of electrical equipment.

Division 2 locations where ignitable concentrations of flammable gases or vapors can exist are:

- Failure of closed containment systems
- Abnormal operation or failure of processing and ventilation equipment
- Area is adjacent to a Division 1 location.

In Class I areas that utilize the division concept methodology, four distinct groups are based solely on the liquid or gas ease of ignitability and its corresponding range of flammability. Fig. 1 illustrates this concept.

Group A—atmospheres that contain acetylene

Group B—flammable gas or vapor atmospheres having either a maximum experimental safe gap (MESG) less than or equal to 0.45 mm or a minimum ignition current (MIC) ratio less than or equal to 0.40 mm.

Group C—flammable gas or vapor atmospheres having either an MESG greater than 0.45 mm and less than or equal to 0.75 mm or an MIC ratio greater than 0.40 mm and less than or equal to 0.80 mm.

Group D—flammable gas or vapor atmospheres having either an MESG greater than 0.75 mm or an MIC ratio greater than 0.80 mm.

The explosive ranges, as indicated in Fig. 1, are based on normal atmospheric pressure and temperature. As the mixture temperature increases, the flammable range shifts downward. As the mixture temperature decreases, the flammable range shifts upward. It can be easily determined from examining the graph that the mixture volatility is much greater for Group A mixtures compared to Group D mixtures.

Classes of combustible liquids include Class II which is any liquid with a flash point greater than 100°F and less than 140°F. Class III liquids are liquids with a flash point greater than 140°F. Class III liquids are further divided as either Class IIIA liquids or Class IIIB liquids. Class IIIA liquids have a flash point greater than 140°F and less than 200°F. Class IIIB liquids have a flash point greater than 200°F. The Occupational Safety and Health Administration states in 1910.106 (a)(18)(iii) that, when a combustible liquid is heated to within 30°F of its flash point, it shall be handled in accordance with the requirements of the next lower class of liquids. If the material is a combustible liquid that is not

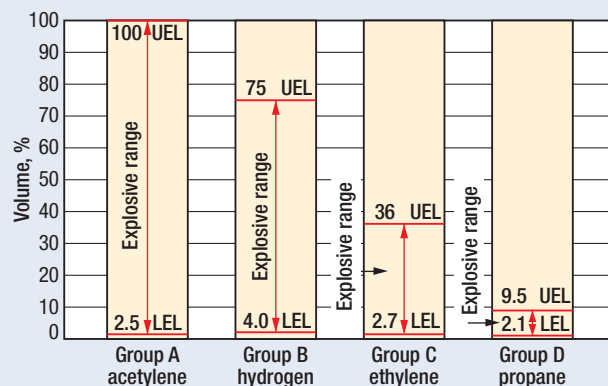
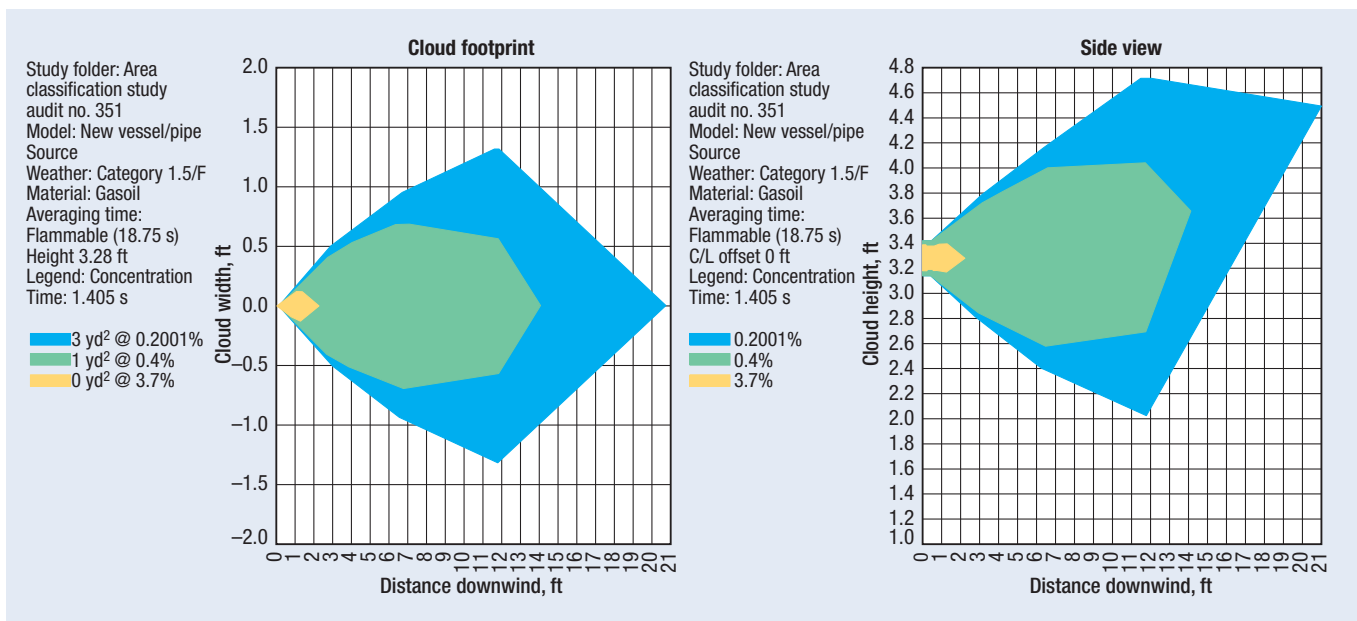


FIG. 1 Explosive range by vapor grouping.



**FIG. 2** Class III liquid vapor cloud dispersion.

heated to within 30°F of its flash point, then the area does not need to be classified. The other and most encountered scenario is when the combustible liquid is heated within the process to several hundred degrees in excess of its flash point. This is typical in refinery and petrochemical operations in the US.

Fig. 2 represents a vapor dispersion model of a Class IIIIB mixture in a typical refinery operation. Both the vapor cloud footprint and side view are shown, and has a flash point of 180°F. The release scenario is 500 lbs of product through a 0.1 in. orifice leak in a vessel. The process pressure is 220 psig at 675°F. The area shown in green is the vapor cloud mass that is above the lower flammable limit and below the upper flammable limit. This mass is in the explosive or flammable region. The ignitable portion of the vapor cloud extends outward some 14 ft. Notice that the flammability range was reduced significantly by the increase in process temperature (from 6 to 13.5% in air to 0.4 to 3.7% in air).

**Class II areas.** These are hazardous locations because combustible dust is present. Combustible dust is defined as any solid material 420 microns or less in diameter that present a fire or an explosion hazard when dispersed in air. Like Class I areas, Class II areas are also divided into two distinct divisions that again depend on operational interpretation of normal vs. abnormal.

Division 1 is a location where combustible dust is present in the air:

- Under normal operating conditions, in quantities sufficient to produce an explosive or ignitable mixture
- The dust is electrically conductive. Dusts are considered to be electrically conductive if the electrical resistivity of the solid material from which the dust is formed has a value of less than 10<sup>5</sup> ohm-cm.
- Releases from faulty operation of process equipment result in the simultaneous failure of electrical equipment, causing the electrical equipment to become a source of ignition.

Division 2 is a location where combustible dust is:

- Present in the air only under abnormal operating conditions in quantities sufficient to produce an explosive or ignitable mixture.

- Accumulations are normally insufficient to interfere with the normal operation of electrical equipment or other apparatus, but combustible dust could be in suspensions in the air due to infrequent process equipment malfunctions.

- 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 electrical equipment failure.

The following information contained in Table 1 is a rule-of-thumb guideline in determining dust layer accumulation vs. the required classification. The dust accumulations in Table 1 are based upon a 24 hr build-up on horizontal surfaces.

In Class II areas, three distinct groups are based primarily on the physical characteristics of the dust:

Group E—atmospheres that contain combustible metal dusts, including aluminum, magnesium and their commercial alloys, or other combustible dusts whose particle size, abrasiveness and conductivity present similar hazards in the use of electrical equipment.

Group F—atmospheres containing combustible carbonaceous dusts that have more than 8% total entrapped volatiles or that have been sensitized by other materials so that they present an explosion hazard. Representative combustible dusts that fall into this grouping are coal, carbon black, charcoal and coke.

Group G—atmospheres containing other combustible dusts, including flour, grain, wood flour, plastic and chemicals.

Explosion severity is a measure of the damage potential of the energy released by a dust explosion. The US Bureau of Mines (USBM) has defined the equation for calculating explosion severity as:

$$\text{Explosion severity} = \frac{(P_{\max} \times P)_2}{(P_{\max} \times P)_1}$$

where:

$P_{\max}$  = maximum explosion pressure

$P$  = maximum rate of pressure rise

Subscript 1 refers to the values used for Pittsburgh seam coal.

where:

$$P_{max} = 8.1 \text{ bar}$$

$$P = 214 \text{ bar/sec}$$

Subscript 2 refers to the values for the specific dust in question.

Ignition sensitivity is a measure of the ease by which a cloud of combustible dust can be ignited. The USBM has defined the equation for calculating ignition sensitivity as:

$$\text{Ignition sensitivity} = \frac{(T_c \times E \times M_c)_1}{(T_c \times E \times M_c)_2}$$

where:

$T_c$  = minimum ignition temperature

$E$  = minimum ignition energy

$M_c$  = minimum explosion concentration

Subscript 1 refers to the values used for Pittsburgh seam coal.

where:

$T_c = 591^\circ\text{C}$

$E = 160 \text{ mj}$

$M_c = 70 \text{ g/m}^3$

Subscript 2 refers to the values for the specific dust in question.

Dusts that have ignition sensitivities equal to or greater than 0.2 or explosion severities equal to or greater than 0.5 are considered to have enough volatility to warrant locations processing these dusts to be classified. The material published by the USBM is no longer in print and copies are hard to find.

**Class III areas.** These are hazardous locations because easily ignitable fibers and flyings are present. In Class III areas, there are no groupings as in Class I and Class II areas. There are, however, divisions that are based on how the material is processed. Division 1 is a location where easily ignitable fibers producing combustible flyings are handled, manufactured or used. Division 2 is a location where easily ignitable fibers are stored or handled other than in the manufacturing process.

**Risk-assessment methodology development.** A risk-assessment methodology must be developed prior to beginning the actual area classification assessment itself. This methodology sets the ground rules by which the assessment is conducted. The deliverables presented at the completion of the assessment methodology are:

- Key members of the assessment team are identified, along with their respective roles and responsibilities required to support the assessment process. Typically, this core team will consist of an operations representative, a mechanical integrity representative, the individual who is conducting the actual assessment and a process engineer.

- The assessment concept point source vs. the blanket classification will be determined.

- All potential point sources of emissions will be identified. Point sources are process equipment that continuously or intermittently release flammable vapors into the atmosphere during routine modes of operation. Typical equipment that should be considered are: mechanical pumps seals, valve packing, overpressure protection devices, filters, compressor seals, process drains and vents and all hydrocarbon-containing pressure vessels.

- Such terms as normal vs. abnormal and frequent vs. infrequent are operationally defined.

- How to address the following scenarios is determined: the extent of classified areas that extend beyond unit battery limits, the extent of classified areas that extend into roadways, areas where ignition sources other than electrical are present under normal operating conditions,

**TABLE 1. Dust layer accumulation vs. classification**

Dust layer thickness	Recommended classification
Greater than 1/8 in. (3 mm)	Division 1
Less than 1/8 in. (3 mm), but color not discernable	Division 2
Surface color discernable under the dust layer	Unclassified

areas where pipe bridges and racks either cross or are adjacent to roadways, the impact of facility or unit operational history, and the discovery of errors and omissions in documentation.

- How the various codes and standards writing organizations will apply. Typically, the National Fire Protection Association (NFPA) is used for all petrochemical applications and the American Petroleum Institute (API) is used for refinery applications.

- It is determined whether the division or zone concept will be utilized. Typically, the division concept is used in the US and the zone concept is used in Canada and Europe.

- The authority that has jurisdiction is identified.

**Area classification assessment.** Once the risk assessment methodology is developed, then the actual process of classifying the area is ready to begin. A typical assessment study will include seven basic steps:

**Step 1.** Obtain the required documentation that was determined from the assessment methodology. Provide a lower level view of the process for equipment identification and process arrangements.

**Step 2.** Field-survey the area in question to determine if the plot plans are accurate and verify location of all point sources of emissions.

**Step 3.** Determine the classified area extent that surrounds each point source of emission. This will determine the role that each point source will play in the overall composite area classification diagram. The extent of classification diagrams should come from NFPA 497 for petrochemical applications, API RP500 for petroleum refinery applications and/or gas dispersion modeling software tools. Gas/vapor dispersion modeling software should be utilized when one out of these three scenarios exists:

- 1) Extreme process conditions are encountered such as large flowrates > 250 gpm, pressures > 275 psig and liquids with a vapor pressure > 70 psia at operating temperature.

- 2) Combustible liquids are heated to temperatures > 100°F of their respective flash points.

- 3) The stream composition is a complex mixture of hydrocarbons.

**Step 4.** Develop the composite area classification plan drawing that embellishes the contribution of all point sources.

**Step 5.** Develop elevation drawings to provide clarity where there are emission sources located in multilevel process structures. A plan view will be required for each level in the process structure.

**Step 6.** Conduct the compliance audit.

**Step 7.** Create a detailed assessment report that documents the following information:

- The rationale used to classify the areas
- The critical process material information usually obtained from the material safety data sheets
  - A detailed listing of all point sources of emissions that appear on the drawings
  - Special out-of-the-ordinary exceptions that were taken when classifying a particular location
  - The results or findings obtained from the compliance audit

- A vapor dispersion modeling graph.

All area classification documentation should be placed under the protection of the facilities management of change process control. As modifications are made to the facility, these documents should be reviewed to verify the impact of these modifications.

**Protection methods and hazard reduction.** Hazard reduction is where a facility reduces the probability or risk of significant property damage and/or loss of life as the result of an explosion or a fire. It helps ensure that installing electrical equipment in a hazardous location does not significantly raise the risk or probability of an explosion or a fire. This is the point where steps are taken to provide compliance with the area classification assessment. Mitigation options are discussed and corresponding action items are carried out.

**Protection methods in Class 1 areas.** It is important to follow the key protection methods:

- Physically isolate the hazard by placing or relocating the normal arc-producing electrical devices to a nonhazardous area. This is an attractive option when approved equipment for the classified area is not readily or commercially available.
- Confining the explosion is the most common and widely accepted protection method. It deploys the use of devices that are vendor-certified, through listing or labeling, as explosion-proof. Explosion-proof means that the device enclosure is designed and tested in a manner that guarantees if a flammable vapor enters the enclosure and is ignited by an electrical arc or a hot surface within the enclosure, the resulting explosion is contained within the enclosure. The electrical apparatus contained within the enclosure should still be operational.
- Energy limiting is known as an intrinsic safety measure, that prevents ignition by limiting the released energy resulting from wiring and component failures or faults. Underwriters Laboratory listed intrinsically safe electrical devices are incapable of releasing enough energy under normal or abnormal conditions to cause ignition of a specific hazardous atmosphere in its most easily ignitable concentrations.

• Hermetically sealed types of protection ensure that arc- or heat-producing devices are sealed against the intrusion of the hazardous vapor.

• Pressurization is the process of supplying an enclosure with a protective gas with or without continuous flow to prevent the entrance of a flammable vapor, combustible dust or ignitable fiber.

• Purging is the process of supplying an enclosure with a protective gas at a sufficient flow and positive pressure to reduce the concentration of any flammable vapor initially present to a safe level.

**Pressurized system types.** Type X reduces the classification within a protected enclosure from Division 1 to unclassified.

The design requirements for a Type X purge system are the following:

- A positive pressure > 0.1 in. of water with equipment energized should be maintained.
- Exchange four enclosure volumes of purge gas before energizing components with a required interlock.
- An interlock is required to remove power from internal electrical components in the enclosure when the purge pressure falls below 0.1 in. of water.
- Power from enclosure when enclosure is opened must be removed.

- The pressure alarm must be located in a continuously attended area.

Type Y reduces the classification within a protected enclosure from Division 1 to Division 2. Type Z reduces the classification within the protected enclosure from Division 2 to unclassified. The design requirements for a Type Y or Z purge system are:

- Maintain positive pressure greater than or equal to 0.1 in. of water with equipment energized.
- Exchange four enclosure volumes of purge gas before energizing components (no interlock required).
- Purge system failure must be detected with an alarm.

The oil immersion protection method is where the arc-producing or heat-generating devices are immersed in oil thereby eliminating the intrusion of potentially hazardous vapors. This method can only be used for Division 2 areas.

**Protection methods in Class II areas.** It is important to follow the key protection methods:

- Physically isolate the hazard in the same manner as for Class I areas.
- Utilization of dust ignition-proof equipment requires two things: 1) the enclosure is dust-tight, and 2) the enclosure is constructed so that heat generated inside will not ignite a dust layer on or a combustible cloud surrounding the enclosure.
- Purging may be used as long as the NFPA 496 requirements are followed.
- Energy limiting is at the same level of protection as in Class I areas.

**Protection methods in Class III areas.** These areas employ the same methods that were utilized for Class II areas. The basic requirement is to make use of dust-tight enclosures for all normal arc-producing electrical devices. **HP**

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**Jim Johnston** is a professional engineer for Bath Engineering Corporation. He has become nationally recognized through his expertise on site evaluation and compliance auditing regarding issues on electrical safety in hazardous locations. Mr. Johnston's knowledge is derived from his more than 34 years with the petrochemical and petroleum refining industries where he designed process safety shutdown systems, performed electrical safety reviews, implemented compliance design solutions, participated in process safety reviews, and installed field instrumentation application and control system designs. He has authored several technical papers on electrical safety in hazardous locations and has presented these papers in symposiums and participated in technical conferences throughout the US. Mr. Johnston received his BS degree in electrical engineering from the University of Houston.