How to Choose the Right Electric Motor for the Chemical Process Industry – Part 1 of 5

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Operating an electric motor in a hazardous location poses risks that range from production downtime to injury and death. In this series of articles, learn how to select the appropriate motor for your operating environment in the chemical process industry.

Classify the Operating Area: NEC/CEC Methods

In this introductory article, we will look at how hazardous environments are classified. Other articles in this series will look at electric motor types suitable for these environments.

Electric motors may arc or spark, and they operate at high enough temperatures to pose a serious threat in environments that contain combustible materials. In most cases, the result will be minor process downtime, but given the right set of circumstances there may be serious injury or even death.

No operator should feel insecure about their energy generation equipment, so for safety and ease of mind, everyone should be aware of which electric motors are the best choice for the environment they will be working in every day.

Choosing the best electric motor for the work area requires four key pieces of information: the class, division, and group classification of the environment, and the autoignition temperature

(AIT) of the hazardous material in question. In this article, we will look at each of these key points in order to clarify the different industry safety standards.

In North America, hazardous classifications are defined by the United States' National Electrical Code (NEC) [1] and the Canadian Electrical Code (CEC) [2]. These codes also stipulate requirements for the design and labeling of motors that are allowed to operate in these environments. In general, these two systems have extensive overlap (although their terminology is not always the same). For those doing across-border work, however, both systems should be consulted before designing a system.

Location Classes

The NEC and the CEC define three classes of hazardous locations based on the type of material present: gases and vapors, combustible dusts, and fibers, filings, and flyings.

Class	Description
I	Gases and Vapors
II	Combustible Dusts
III	Fibers, Filings, and Flyings

Class I: These locations contain flammable gases or vapors in sufficient quantities in the atmosphere to pose a risk of explosion or ignition. Petroleum processing facilities, for example, are often considered Class I hazardous locations due to the presence of gaseous hydrocarbons.

Class II: These locations contain dust that is either electrically conductive or could be explosive when mixed with air. This class has some hidden dangers, as dusts can move from being harmless to deadly at different concentrations. Some dusts, such as flour for example, may seem harmless but when distributed in the air at a high enough concentration can be extremely explosive. Dusts can also react differently from their solid forms. Electrically conductive materials, such as aluminum and magnesium, for example, will burn when in a consolidated mass but are potentially explosive when suspended in air.

Class III: These locations are characterized by the presence of easily ignitable fibers, filings, or flyings (particles that accumulate but are not suspended in the air). Class III locations are typical in textile industries (e.g., cotton lint) where materials are too heavy to remain in the air and therefore tend to settle on equipment and on the ground. As anyone who owns a clothes dryer knows, if such by-products accumulate around heat-producing electrical equipment, they can ignite.

This hazardous class is encountered less frequently in the chemical process industries than the other two classes and generally only in a few specific sectors. For this reason, the selection of motors for Class III areas is not discussed in this article.

Division Conditions

Class is determined by the type of material present, and each of these three classes is further divided into divisions that describe conditions under which material is present. In other words, division considers how likely it is that the class materials will catch fire or explode.

Division	Description
1	Ignitable concentrations of hazards exist under normal operation conditions.
2	Ignitable concentrations of hazards exist under abnormal operation conditions.

Division 1. A Division 1 location is one in which an explosive or ignitable material is present under normal operating conditions. The material need not be present at all times, but it must be present at least intermittently during normal operations. Division 1 locations include, for instance, environments where explosive materials are routinely exposed to the atmosphere during regular operation and scheduled maintenance.

Division 2. In contrast, a Division 2 location is one in which an explosive or ignitable material is

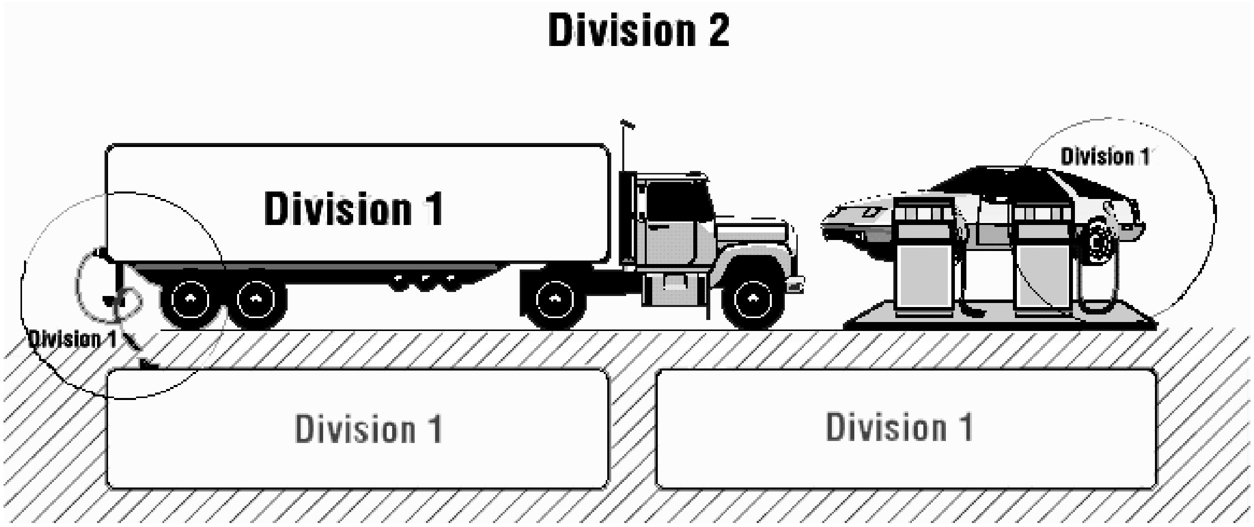

Figure 1. FOR ILLUSTRATION PUPOSES ONLY. The Division 1 areas are those that contain ignitable materials under normal operating conditions. The Division 2 area is defined as containing ignitable materials only under abnormal conditions (e.g., a leak).

SOURCE: http://literature.rockwellautomation.com/idc/groups/literature/documents/wp/800-wp003_-en-p.pdf

present under abnormal operating conditions.

Although gas stations are not classified with divisions, Figure 1 serves as a useful illustration of the differences between Division 1 and Division 2. At this hypothetical gas station, Division 1 locations are where an explosive material (gasoline) is present under normal conditions, and the Division 2 location is where ignition or explosion of materials would happen only under the abnormal conditions of a containment failure that results in a leak or spill.

Group Classifications

Group classifications directly follow from the class categories. Groups are based on the ignition temperatures and explosive pressures of Class I and Class II materials. (Note that Class III fibers and flyings, such as hemp, cocoa fiber, and cotton, have no specific groupings.) Group classifications are based on the behaviour of hazardous material after it has been ignited.

Gases and vapors (Class I materials), the most common hazard in industrial chemical environments, are divided into four groups based on maximum explosive pressures. Group A includes only acetylene, a colorless hydrocarbon gas that creates an intense explosion when ignited. Group D, in contrast, contains materials such as ammonia and propane, which will also explode, but will not react as violently as acetylene (Table 1).

Table 1. Examples of Class I and Class II Hazardous Materials

Class	Group	Hazardous Material
Class I	A	Acetylene
	B	Butadiene
		Ethylene Oxide
		Hydrogen
	C	Acetaldehyde
		Cyclopropane
		Diethyl Ether
		Ethylene
		Isoprene
	D	Acetone
		Ammonia
		Benzene
		Butane
		Ethane
		Ethanol
		Gasoline
		Methane
		Propane
		Styrene

Class	Group	Hazardous Material
Class II	E	Aluminum
		Bronze
		Chromium
		Magnesium
		Titanium
		Zinc
	F	Coal
	G	Corn
		Nylon
		Polyethylene
		Sugar
		Wheat
		Wheat Flour

Autoignition Temperatures

The final piece of information that is needed to classify a hazardous location is the autoignition temperature (AIT; also known as the minimum ignition temperature or kindling point) of hazardous materials. The AIT refers to the minimum temperature at which there is sufficient energy for a material to ignite spontaneously, even without a spark, flame, or other source of ignition.

The theoretical AITs of hazardous materials are determined through standard testing procedures. In practice, however, actual AITs may vary significantly from published values because AIT is affected by several factors, including oxygen concentration, pressure, and system volume. Therefore, literature values of AIT should be considered guides rather than definitive parameters for the safe operation of electric motors.

AITs for Mixtures

Another important consideration is that the AITs of mixtures of hazardous gases cannot easily be determined and guides are not available. A common solution is to consider only the lowest AIT of all the component gases, although this approach is likely to be overly conservative. There is no easy solution here, as good judgement will only come from practical experience in the field. The AITs of various Class I hazardous materials are provided in Table 2.

Table 2. Autoignition Temperatures of Class I Materials

Class	Division	Group	Hazardous Material	Autoignition Temperature °C	Autoignition Temperature °F
Class I	Divisions 1 and 2	A	Acetylene	305	581
		B	Butadiene	420	788
			Ethylene Oxide	570	1,058
			Hydrogen	500	932
		C	Acetaldehyde	175	347
			Cyclopropane	498	928
			Diethyl Ether	180	356
			Ethylene	450	842
			Isoprene	398	743
		D	Acetone	465	869
			Ammonia	651	1,204
			Benzene	498	928
			Butane	287	550
			Ethane	472	882
			Ethanol	363	685
			Gasoline	246–280	475–536
			Methane	537	999
			Propane	450	842
			Styrene	490	914

In the next article, we will look at the international IEC classifications and contrast them to the NEC and CEC classifications.

References

1. National Fire Protection Association, National Electrical Code, NFPA 70, NFPA, Quincy, MA (2011).
2. Canadian Standards Association, Canadian Electrical Code, C22.1, CSA, Mississauga, ON (2009).