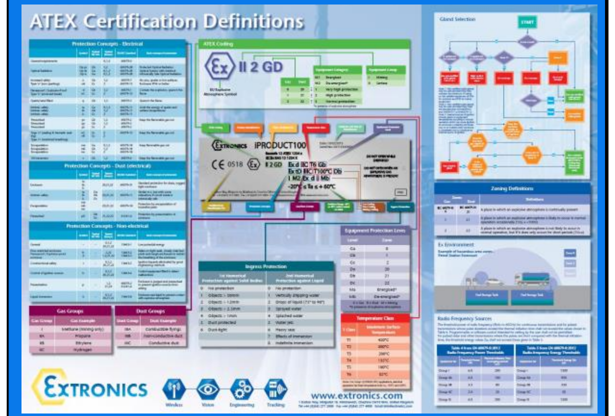
REFINERIES EXPLOSION AREA CLASSIFICATION STANDARDS

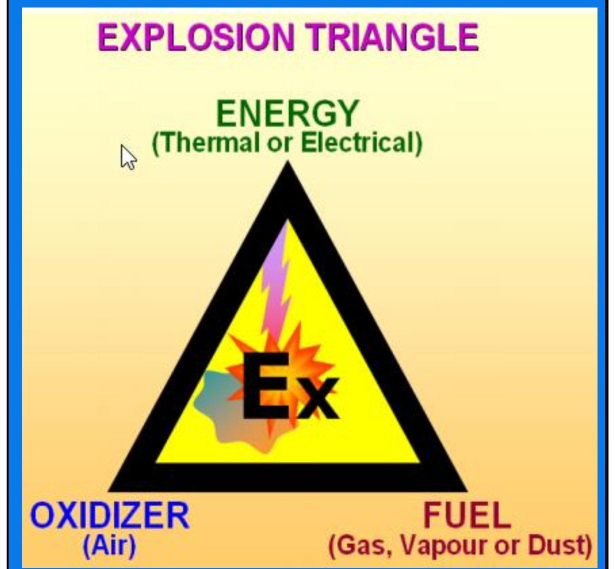
47

SAFETY MANAGER!

An accidental explosion in a hazardous location could mean serious injury for an employee.

Only an Authorised supervisor should decide the Lighting ATEX Category for each Zone after strict evaluation.





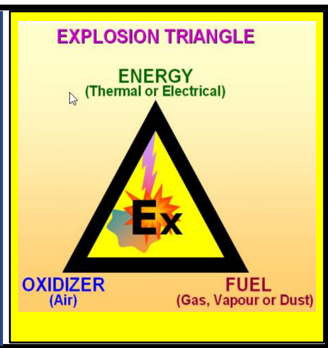
STANDARDS

- International — IEC 60 079 series
- European — CENELEC 60 079 series
- National — USA : ANSI/API RP 505 (zone system); Russia : Gost R 51330-X-99 series

https://www.pelicatalogue.com/nl/node/921

https://hseengineer.wordpress.com/hazardous-area-classification-guidelines/

https://en.wikipedia.org/wiki/Electrical_equipment_in_hazardous_areas



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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

Process and HSE Engineering
A Professional Blog for HSE, Process and Safety engineer

STANDARDS

▪	**International**	**IEC 60 079 series**
▪	European	CENELEC 60 079 series
▪	National	USA : ANSI/API RP 505 (zone system)
		Russia : Gost R 51330-X-99 series

Hazardous Area Classification – Guidelines

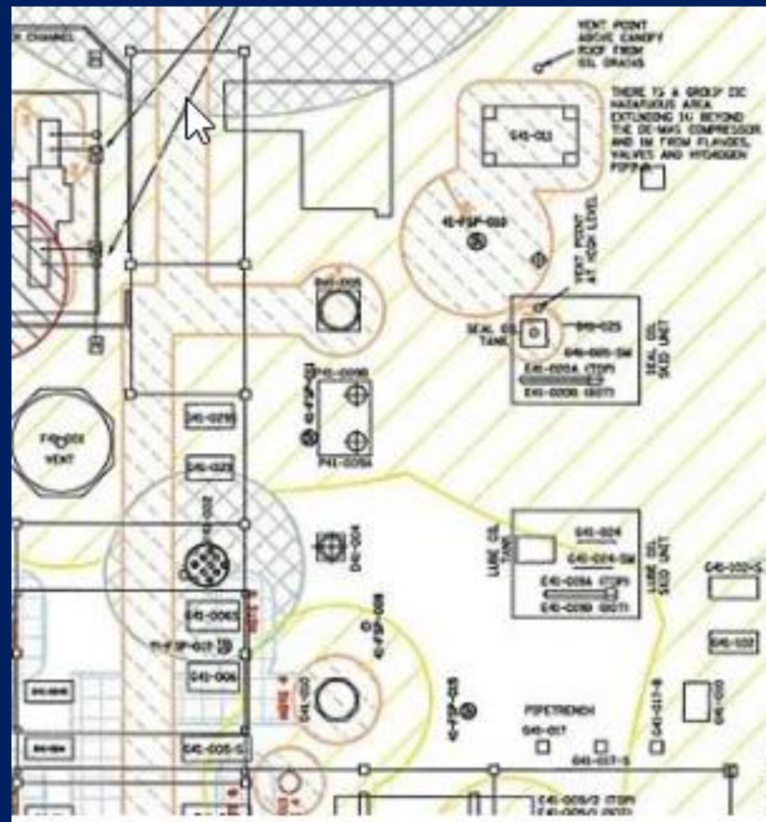
Purpose:

The scope of this guide is to drawn the guidelines of several different Recommended practice(s) for the Area Classification of a process plant. The area classification is required for the installation of the electrical equipment with the related specific protection kind within a process area. The basic definition, and the following modifications is based mainly on the 1996 NFPA 70, The national Electrical Code (NEC) and the API 505 Recommended Practice (API RP 505). Once that a location has been classified, requirements for electrical equipment and associated wiring should be determinate from applicable publications (e.g. NFPA 70 and API Recommended Practice 14F (API RP 14F) and local regulations.

The final scope of the document is to achieve the classification of both permanently and temporarily installed electrical equipment. The application is designed in relation to their potential risk of ignition source in presence of an ignitable mixture of "fuel", or a flammable/ignitible substance, and Oxygen (Air) under normal atmospheric conditions.

Reference Atmospheric Conditions		
Pressure	*101.3 Kpa*	*14.7 Psia*
Temperature	*20°C (293.15 K)*	*68°F*

The document provides that is no relevant changes related to the change of the atmospheric conditions from the reference point. On the basis provided earlier, the guide is developed on the recommended practice based on the petroleum facility zones (where ignitable liquids, gases, and vapors are processed, handled and loaded).



References, Codes and Reference Standards:

Actually, there are many Reference standards and industrial codes as reference for the plant area classification. Part of them are developed on the same basis, others are very particular and applied in specific plant type (e.g. Drilling Facilities, Petroleum and petrol chemical plants).

The Hazardous Area Classification presents in this guide is based on the following items as reference:

API:

API RP 505 Recommended Practice for Classification of Locations for Electrical Installation at Petroleum Facilities Classified as Class I, Zone 0, Zone 1 and Zone 2 (2002).

API RP 500 Recommended Practice for Classification of Locations for electrical Installation at Petroleum Facilities Classified as Class I, Division 1 and Division 2.

IEC:

IEC 60079-10 Electrical Apparatus for explosive gas atmospheres- Part 10: Classifications of hazardous Area.

IEC 60079-12 Classification of Mixtures of Gases or vapors with air according to their maximum experimental Gaps (MEGs) and minimum ignition currents ratio (MIC).

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IEC 60079-20 Electrical Apparatus for explosive gas atmospheres- Part 20: Data for flammable gases and vapors, relating to the use of electrical apparatus.

NFPA:

NFPA 30: Flammable and Combustible Liquids Code

NFPA 70: National Electrical Code

NFPA 325: Guide to fire Hazard Properties of Flammable Liquids, Gases, and volatile Solids

NFPA 497: Recommended practice for the Classification of Flammable Liquids, Gases or Vapors and of Hazardous (classified) Locations for Electrical Installations in Chemical Process Areas.

Basic Definitions:

The following list of definition is based on the reference codes and practice guideline listed before. The reference standard is assigned to each definition.

Boiling Point – The temperature of a liquid boiling at the reference atmospheric conditions. (IEC 79-10, Mod.)

Area Classification – See Further paragraph named ("Area Classification and Definition").

Class I, Zone 0 – See Further paragraph named ("Area Classification and Definition").

Class I, Zone 1 – See Further paragraph named ("Area Classification and Definition").

Class I, Zone 2 – See Further paragraph named ("Area Classification and Definition").

Combustible Liquid(s) – See Flammable Liquid(s) definition.

Enclosed Area – A three-dimensional space enclose by more than two-third (2/3) of the possible projected plane surface area and of sufficient size to allow the entry of personnel. For a common building, this would required two-third (2/3) of the walls, ceiling, and/or floor be present.

Explosive gas atmosphere – A mixture with air, under the reference atmospheric conditions, of a flammable material in the form of gas or vapor which, after ignition, combustion spreads throughout the unconsumed mixture. (API 505-3.2.20)

Flammable – Capable of an easy ignition, burning intensely or spreading flame rapidly.

Flammable (Explosive) limit(s) – The lower (LFL) and upper (UFL) percentages by volume of concentration of gas in gas-air mixture that will form an ignitible mixture. (NPFA 325)

Flammable Liquid(s) – See Further paragraph named ("Flammable liquid Classification").

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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

Flash Point – The minimum temperature of a liquid at which sufficient vapor is give off to form an ignitible mixture with air, near the surface of the liquid, or within the vessel used, as determinate by the test procedure and apparatus specified in NFPA 30.

Grade of Release – There are three basic grade of release, as listed below, in order of decreasing likelihood of the explosive gas atmosphere being present.(1)

1- Continuous

2- Primary

3- Secondary

Other grades of release may be possible by combination of the basic ones listed.(IEC 79-10, Mod.)

(1) It is important to underline that there isn't any relationship with the type of release discussed earlier like" puff" and "plume".

Grade of Release: Continuous – See Further paragraph named ("Area Classification and Definition").

Grade of Release: Primary – See Further paragraph named ("Area Classification and Definition").

Grade of Release: Secondary – See Further paragraph named ("Area Classification and Definition").

Gas Group(s) – For the Classification, the ignitible gases or vapors are classified in several different groups. The subdivision of the gases is related to the gases physical and chemical properties.

Hazardous (classified) Location(s) – A location where fire and explosion hazards may exist due to flammable gases or vapors, flammable liquids, combustible dusts, or ignitible fibers of flyings. (API 505-3.2.10.5)

Heavier-than-air Gases of Vapors – Formally those gases of vapors with a relative density above 1.2 as to be regarded as Heavier-than-air gases. (IEC 79-10, Mod.)

Highly volatile liquid(s) (HVL) – See Further paragraph named ("Flammable liquid Classification").

Ignitible (Flammable) Mixture – A gas-air mixture that is capable of being ignited by an open flame, electric arc or spark, or device operating above the ignition temperature of the gas-air mixture. (See "Flammable (Explosive) Limits") (API 505-3.2.32)

Ignition (Auto ignition) Temperature (AIT) – The lowest temperature of a heated surface at which, under specific conditions, the ignition of a flammable substance, or mixture in the form of gas or vapor will occur. (IEC 79-10, Mod.)

POWER

Business & Technology for the Global Generation Industry

https://www.powermag.com/practical-guidelines-for-determining-electrical-area-classification/

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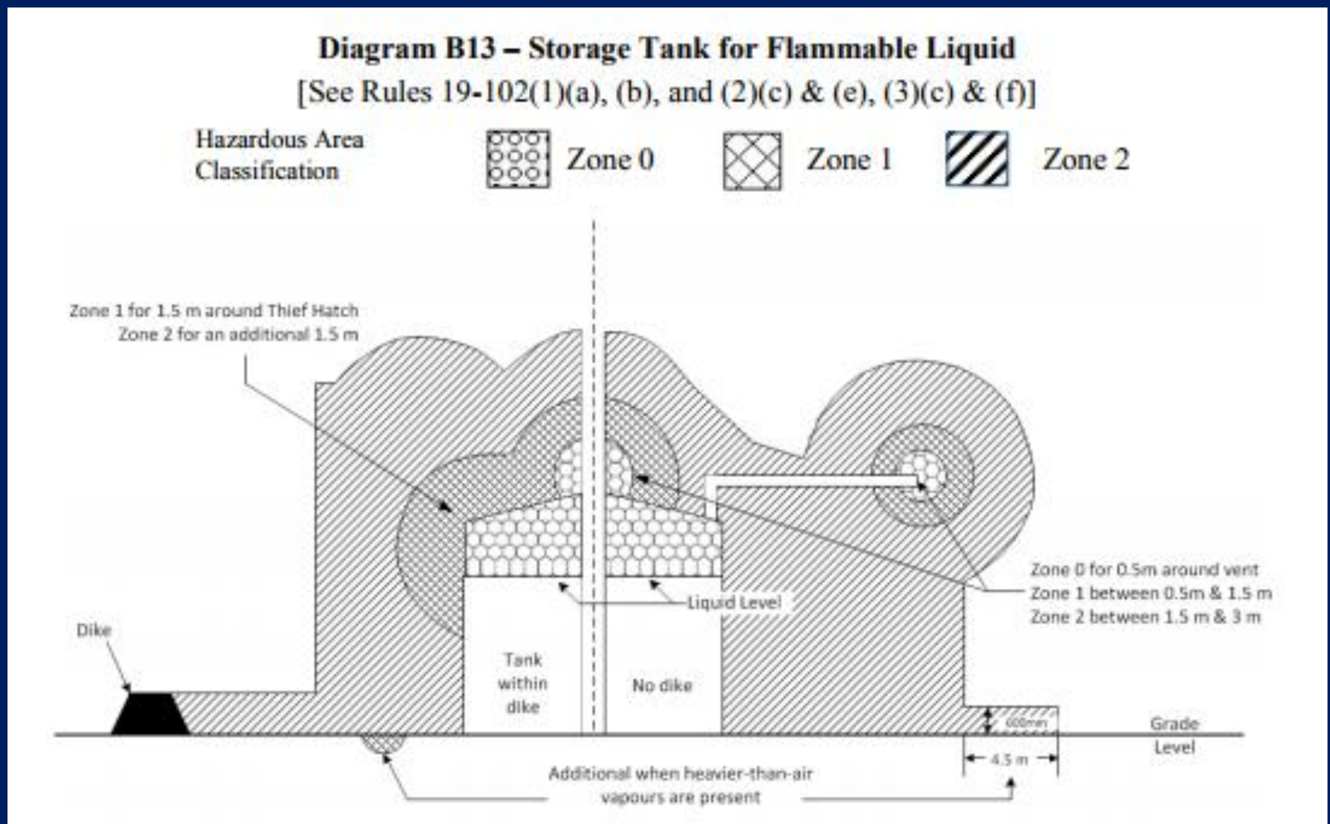
Maximum Experimental Safe Gap (MESG) – The maximum gap of the joint between the two parts of the interior chamber of a test apparatus that, when the internal mixture is ignited and under specific conditions, prevents the ignition of the external gas mixture by propagating through a 25 mm (984 mils) long joint, for all concentrations of the tested gas or vapor in air. (API 505-3.2.38)

Minimum Ignition Current (MIC) – The minimum current that, in a specified spark test apparatus and under specific condition, is capable of igniting the most easily ignitible mixture. (API 505-3.2.39)

Minimum Ignition Current Ratio (MIC Ratio) – The minimum energy required from a capacitive spark discharge to ignite the most easily ignitible mixture of a gas or vapor divided by the minimum current required from and inductive spark discharge to ignite methane under the same test conditions. (NFPA 497)



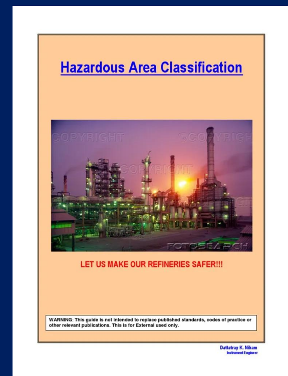
Gases, Vapors and Mists

IEC 60079-10.1 Classification of areas - Explosive gas atmospheres

Zone	Nature and Probability of Hazard Material
Zone 0	Ignitable concentrations of flammable gases or vapors which are present continuously or for long periods of time.
Zone 1	Ignitable concentrations of flammable gases or vapors which are likely to occur under normal operating conditions.
Zone 2	Ignitable concentrations of flammable gases or vapors which are not likely to occur under normal operating conditions and do so only for a short period of time.

Group		Type of Hazardous Material and Location of Atmosphere
Group I		**Mines** susceptible to firedamp (flammable mixture of gases naturally occurring in a mine).
Group II		**Explosive gas** atmosphere other than mines susceptible to firedamp. Group II equipment is subdivided into three subgroups.
	A	Atmospheres containing propane, acetone, benzene, butane, methane, petrol, hexane, paint solvents or gases and vapors of equivalent hazard.
	B	Atmospheres containing ethylene, propylene oxide, ethylene oxide, butadiene, cyclopropane, ethyl ether, or gases and vapors of equivalent hazard.
	C	Atmospheres containing acetylene, hydrogen, carbon disulphide or gases and vapors of equivalent hazard.
Group III		**Explosive dust** atmosphere. Group III equipment is subdivided into three subgroups.
	A	Atmospheres containing combustible flyings.
	B	Atmospheres containing non-conductive dust.
	C	Atmospheres containing conductive dust.

The Engineering ToolBox



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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

Normal Operation(s) – The situation when the equipment is operating within its design parameters. (IEC 79-10, Mod.)

Protected Fire Vessel – Any fired vessel that is provided with equipment (such flame arresters, stack temperature shutdown, forced draft burners, with safety controls, and spark arresters) designed to eliminate the air intake and exhaust as sources of ignition. (API 505-3.2.48)

Release, Source of – A point or location from which a flammable gas, vapor or liquid may be released into the atmosphere such that an ignitible gas atmosphere could be formed. (IEV 426-03.06, Mod.)

Release Rate – The quantity of flammable gas or vapor emitted per unit time from the source of release. (IEC 79-10, Mod.)

Vapor Pressure – The pressure exerted when a solid or liquid is in equilibrium with its own vapor. It is a substance properties linked to the environment condition and determinate by ASTM D 323-82. (IEC 79-10, Mod.)

Vapor-tight Barrier – Is a wall, or barrier that will not allow the passage of significant quantities of gas or vapor at atmospheric pressure. (API 505-3.2.54)

Ventilation – Natural or artificial movement of air and its replacement with "fresh air".

Ventilation, Adequate – Ventilation that is sufficient to prevent the accumulation of enough quantities of an ignitible mixture into a specific location.

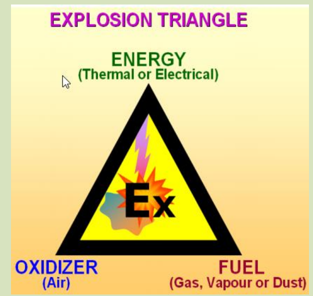
Volatile Flammable Liquid – A flammable liquid whose temperature is above its flash point, or a Class II combustible liquid having a vapor pressure not exceeding 276 Kpa (40 Psia) at 37.8°C(100°F) whose temperature is above its flash point. (API 505-3.2.58)

Basic Condition for Fire(s) and Explosion(s):

As discussed earlier, to occur, a fire and/or and explosion needs three basic elements, without any of them, or specific conditions for each of them, the event cannot occur. The three main elements are: (1) A fuel, not necessary an common combustible (e.g. Dust, or Mill Dust), (2) a combustible (e.g. Air or Oxygen). (3) An igniter source with enough energy to ignite the flammable mixture (e.g. Electrical equipment, free flames, or hot surfaces). Other than the presence of each of these elements, there are two additional conditions needed to obtain a fire or an explosion: (4) The concentration of the fuel within the mixture must be between its own Upper and Lower Flammable Limit. (5) The three basic elements must be in same location, or they must have a position that allows them to complete their own role.

In classifying a particular location, the likelihood of the presence of a flammable gases or vapor is a significant factor in determinate the zone classification (See Further paragraph named "Area Classification and Definition"). Otherwise a distinction must be made: the presence of the flammable mixture could be distinguished between "normal conditions" and "extraordinary condition". The term "extraordinary condition" doesn't mean only a catastrophic event like a violent breakage of an item or similar, but also an ordinary maintenance operation. There is obviously an objection: If an item, or a location, needs a frequent maintenance, the act itself will go under the "normal condition". (API 505.4.2 refers to these condition adopting the phrase "Normal and Abnormal Condition").

As said, the mixture, to occur into an explosion and/or a fire, must have a concentration within its range of flammability. It is quite important to know or to reach an approximation of the quantities of flammable mixture are present inside the different location, to determinate the extension of the area. As more the released quantities are high, as more the area affected by the hazard is wide.



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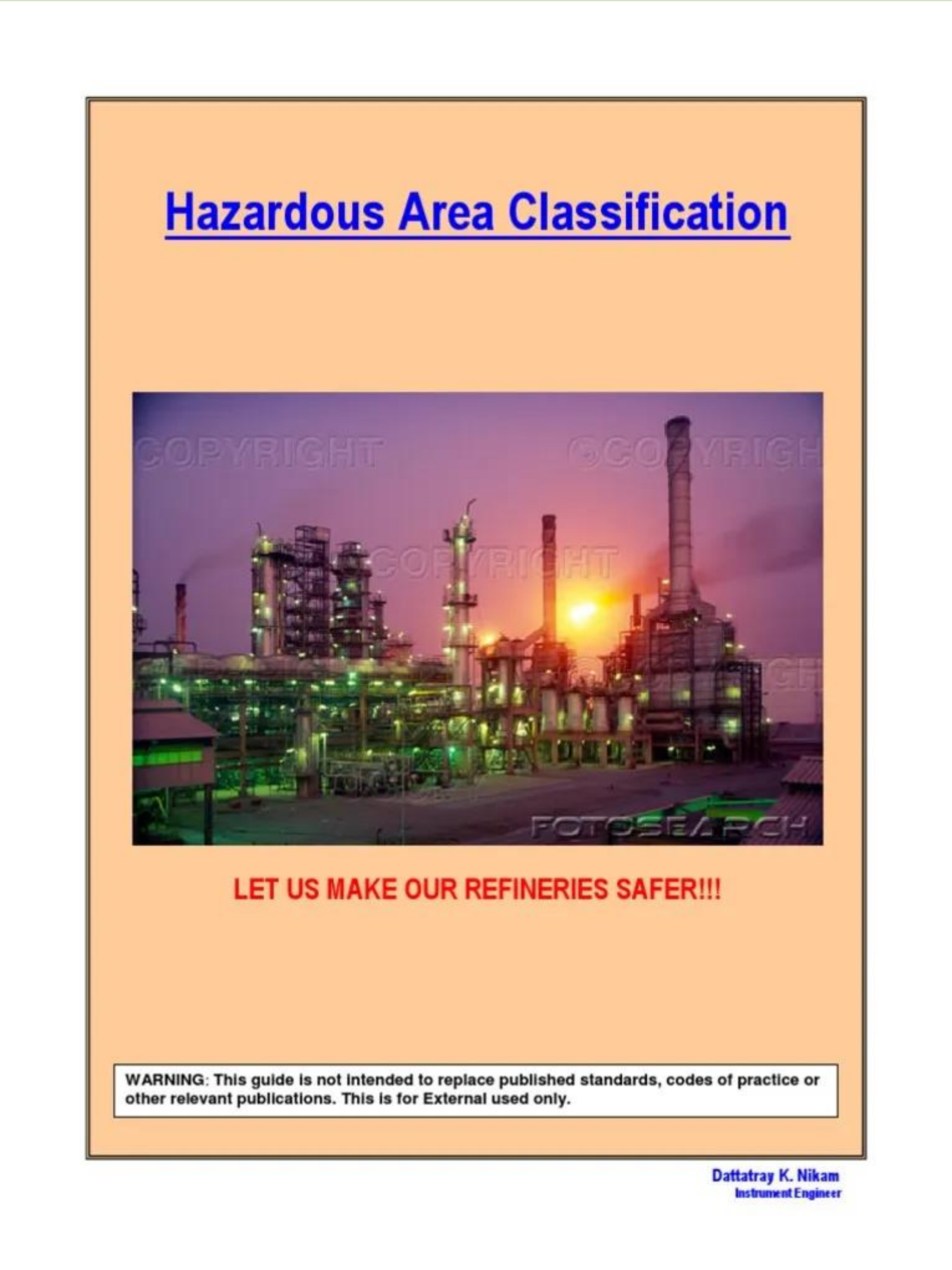

Another relevant parameter to take into account is the ventilation. The ventilation of a specific location can reduce sensibly the hazard connected to a ignitible substance release, even in major case. A good ventilation, natural and/or artificial), especially inside enclosed location, is the fist measure to adopt to reduce the risk of Fires.

Especially for preliminary studies, even before the engineering starts, where the knowledge of the plant and the area is almost unknown, found even and approximate form of these parameters (Likelihood, Concentration, and Ventilation of a specific area) could be really hard, and in the best case the approximation is totally aloof from reality. In fact, the hazardous area classification is commonly made during the entire development of the plant, from the first plot plan revised by the process company to the final general plot plan of the engineering phase, reviewing continuously the data and the area classification.

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Safety Principles:

The area classification must be carried out when the initial process and instrument line diagram (P&ID) are available and will be frequently updated till the start up of the plant. Even during the life of the plant, the classification must be periodically updated, to take into account potential changes to the original plat, or new release source(s).The hazardous area classification, especially its first application, during the process design, must be mainly affected from the inhertly design principles. To start the area classification, it must be identified those area containing hazardous substance, examining those area and identifying the potential sources or points of leakage. The first question the operator should ask himself is "Can these sources be replaced?", avoiding source or any release point it could be the best strategy to adopt, especially when the engineering of the plant even had started. "If the source cannot be avoided, the rate of the release, or its frequency, or its likelihood can be reduced?" the hazard area related to a release is as low as the quantity released, the time of the release and its likelihood is low.

Flammable liquid(s) Classification:

Substances handled by any process facilities include flammable and combustible liquids, flammable highly volatile liquids (HVLs) and flammable gases and vapors. When classifying locations for electrical installations, the appropriate class and group(s) should be determinate for all flammable substances. Each group, and class, is related to the physical and chemical features of the substance. Refer to NFPA 325 or 497 for the properties of specific flammable liquids, gases, vapors and volatile solids. The volatility of flammable and combustible liquids is defined in NFPA 30.

Flammable (Class I) Liquids, such a gasoline, are defined as any liquid having a closed-cup flash point below the threshold of 37.8°C (100°F) and a vapor pressure not exceeding 276 Kpa (14 Psia). Combustible (Class II and III) liquids are defined as liquids having a closed-cup flash point at or above the threshold of 37.8°C (100°F) and below 60°C (140°F). Class III liquids are those liquids having a closed-cup flash point above the threshold of 60°C (140°F)

Flammable and Combustible Liquid(s)

Class	I	II	III
Flash Point Range(°C)	< 37.8	37.8 ÷ 60	> 60
Vapor Pressure(Kpa)	> 276	N.a.	N.a.

A common error is to confuse these classes and liquids group with the Classes of The National Electrical Code, they are not synonymous.(NFPA 70).

Closed-Cup Flash Point and Auto ignition temperature: Another spread error is to confuse the Flash point with the auto ignition temperature.

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"Flash Point – The minimum temperature of a liquid at which sufficient vapor is give off to form an ignitible mixture with air, near the surface of the liquid, or within the vessel used, as determinate by the test procedure and apparatus specified in NFPA 30."

The auto-ignition temperature (AIT) instead, is the temperature, above the flash point, which allow the ignition of the flammable mixture without any ignition source. Adopting the definition of the IEC:

"Ignition (Auto ignition) Temperature (AIT) – The lowest temperature of a heated surface at which, under specific conditions, the ignition of a flammable substance, or mixture in the form of gas or vapor will occur. (IEC 79-10, Mod.)"

The term "Closed-Cup" behind the flash point definition is referred to the standard apparatus adopted for its assessment. There are two basic types of flash point measurement: open cup and closed cup.

In open cup devices the sample is contained in an open cup which is heated, and at intervals a flame is brought over the surface. The measured flash point will actually vary with the height of the flame above the liquid surface, and at sufficient height the measured flash point temperature will coincide with the fire point. The best known example is the Cleveland open cup (COC).

There are two types of closed cup testers: non-equilibrium, such as Pensky-Martens where the vapours above the liquid are not in temperature equilibrium with the liquid, and equilibrium, such as Small Scale (commonly known as Setaflash) where the vapours are deemed to be in temperature equilibrium with the liquid. In both these types the cups are sealed with a lid through which the ignition source can be introduced. Closed cup testers normally give lower values for the flash point than open cup (typically 5-10 °C) and are a better approximation to the temperature at which the vapor pressure reaches the lower flammable limit (LFL).

The flash point is an empirical measurement rather than a fundamental physical parameter. The measured value will vary with equipment and test protocol variations, including temperature ramp rate (in automated testers), time allowed for the sample to equilibrate, sample volume and whether the sample is stirred.

Methods for determining the flash point of a liquid are specified in many standards. For example, testing by the Pensky-Martens closed cup method is detailed in ASTM D93, IP34, ISO 2719, DIN 51758, JIS K2265 and AFNOR M07-019. Determination of flash point by the Small Scale closed cup method is detailed in ASTM D3828 and D3278, EN ISO 3679 and 3680, and IP 523 and 524.
Flash point, and auto-ignition temperature examples are reported above.For further information about Flash point test, and data refer to NFPA 30.

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Flammable Highly Volatile Liquid(s):

The HVLs such butane, propane, propylene, etc, are those flammable liquids of the first class, with a vapor pressure exceeding 276 Kpa (40 Psia) at 37.8 °C (100°F).

Those liquids, have a high volatility and a low Flash point, allowing them to produce a large volume of ignitible mixture. All the precautions must be taken if handled inside the process plant, and they must be treated with ad over conservatively method. Usually the mixture generated has a density lower than air, allowing quick movement and wide distance covered. Those attitudes are the most dangerous and result into a wide process area designed with strictly safety applications.

Class I Liquids:

Class I liquids, with the lowest Flash Point range, are usually handled at temperature above the safety range, consequently can produce a flammable atmosphere. Especially when released into the atmosphere, may produce a large volume of vapors (rarely gases), especially near the source of release. Even if the Class I liquids are generally related to the highest hazard, the less volatile liquids of this class release vapors slowly and the ignition is possible only if the igniter (or the ignition source) is placed near the liquid pool (See."Pool fire").

Class II Liquids:

With class II liquids, the likelihood of ignition is much lower than Class I liquids, due to

their higher flash point, only few of them are usually handled at temperature above their flashpoint. The ignition of a liquid of the Class II usually is taken into account when exposed to a fire, in this case the risk analysis is behind the common threshold of "One emergency only".

Even if they generate vapors, them usually are quite heavy and they cannot move to far from the source. The transition state of the ignitible mixture from Heavier-than-air to lighter-than-air is quite slow.

API RP 505 refers to the Class II liquids as "Do not produce vapors of sufficient quantity to be considered for electrical classification"- (5.2.3.2)

Class III Liquids:

Similar to the Class II liquids, the Class III has a lower likelihood to produce an ignitible atmosphere due to their highest flash point and lowest volatility. If heated beyond its flash point, a Class III liquid produce a small amount of vapor, localized near the point of release.

A partial list of flammable liquids, with the related Class, groups and category are reported into the following pages (NFPA 497 – 1997).

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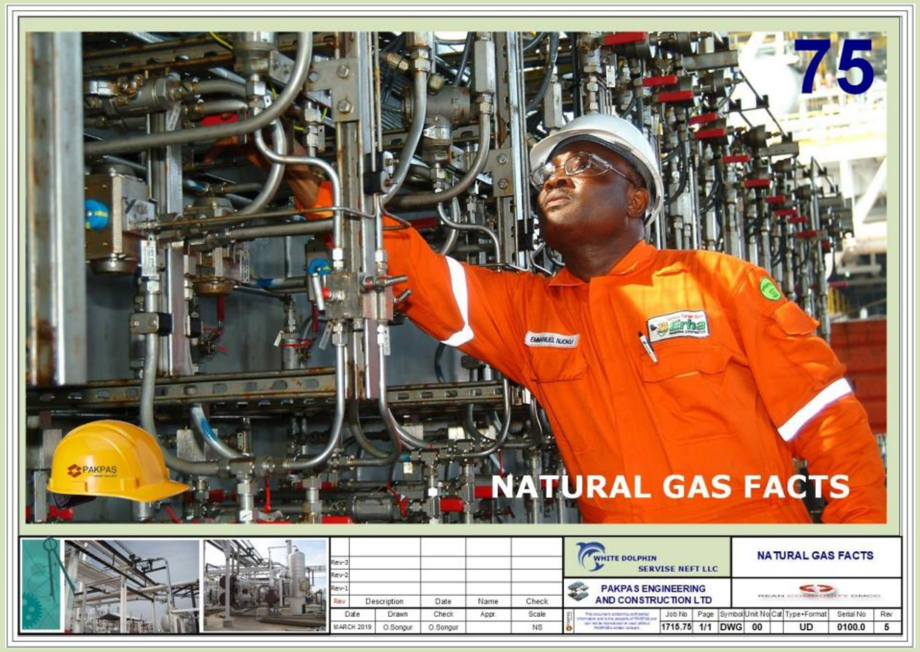
CRUDE OILS:
A specific classification for the crude oils is impossible, its composition is too complex and diversified that even its common physical properties are generic. However crude oil is generally classified as Class I flammable liquid and its flash point range, generally accepted, is -6.7 – 32.2 °C (20-90°F).



Gas Groups:

As done for the hazardous liquids, also the gases are divided into several different groups and subclasses. The first subdivision is the classification into two groups: (1) Group I – Underground Gases and (2) Group II – Aboveground Gases. The first class, is referred to describe atmospheres containing firedamp (a mixture of gases, composed mostly by methane, found usually in mines). For this reason the group I of flammable gases are not used during the Hazardous area classification. The second group is use d to describe all the gases found above ground and is subdivided into IIC; IIB and IIA according to the nature of the gas or vapor. The last three categories of gases are defined by two physical properties of the substance: Maximum experimental allowable gap(s) (MEGS) and the Minimum Ignition current ratio.

Maximum Experimental Allowable Gap:

The MESG is defined as follow:
"Maximum Experimental Safe Gap (MESG) – The maximum gap of the joint between the two parts of the interior chamber of a test apparatus that, when the internal mixture is ignited and under specific conditions, prevents the ignition of the external gas mixture by propagating through a 25 mm (984 mils) long joint, for all concentrations of the tested gas or vapor in air. (API 505-3.2.38)"

	Flash Point °C	*AIT °C*
Benzene	*12*	*560*
Ethyl Alcohol	*55*	*365*
Gasoline	*-45*	*280*
N-Butane	*-76*	*405*
N-Hexane	*-54*	*225*
I-Butane	*-117*	*462*

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The maximum experimental safe gap of flammable gases and vapors is the lowest value of the safe gap measured according to IEC 60079-1-1 by varying the composition of the mixture ("flame propagation in the most ignitibie mixture").The safe gap is the gap width at which in the case of a given mixture composition, a flashback just fails to occur. The test procedure and its parameters are fully describe in IEC 60079-1-1.

Minimum Ignition Current Ratio (MIC Ratio):

The MIC RATIO is defined as follow:
"Minimum Ignition Current Ratio (MIC Ratio) – The minimum energy required from a capacitive spark discharge to ignite the most easily ignitible mixture of a gas or vapor divided by the minimum current required from and inductive spark discharge to ignite methane under the same test conditions. (NFPA 497)" For further information about the MIC Ratio refer to IEC 60079-3.

Gas Group IIA:

Atmospheres containing Acetone, Ammonia, Ethyl Alchol, Gasoline, Methane, propane or flammable gas, flammable liquid produced vapor, or combustible liquid mixed with air that may burn or explode having either a MESG value greater than 0.90 mm or a minimum igniting current ratio (MIC Ratio) greater than 0.80 (NFPA 497 or IEC 60079-10)

Gas Group IIB:

Atmospheres containing acetaldehyde, hydrogen, of flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode having either a maximum experimental safe gape (MESG) greater than to 0.50 mm (20 mils) and less than or equal to 0.90 mm (35 mils) or a minimum igniting current ratio (MIC Ratio) greater than 0.45 and less than or equal to 0.80 (NFPA 497).

Gas Group IIC:

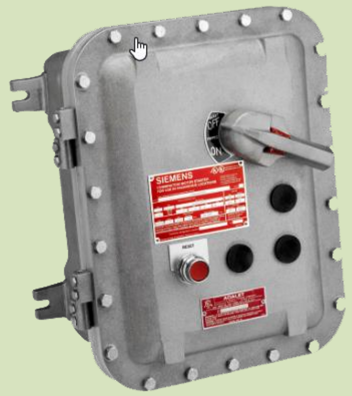
Atmospheres containing acetylene, hydrogen, of flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode having either a maximum experimental safe gape (MESG) greater than or equal to 0.50 mm (20 mils) or a minimum igniting current ratio (MIC Ratio) less than 0.45 (NFPA 497).

For the most gases and vapours it is sufficient to make only one determination between the MESG and MIC Ratio to relate the gas to its own group. There are some cases which both determination are required:

a) When MIC Ratio is within the range 0.8 – 0.9.
b) When MIC Ratio is within the range 0.45 – 0.5.
c) When MESG is within the range 0.5 – 0.55

Group II			
	IIA	IIB	IIC
MESG (mm)	> 0.90	0.50 < < 0.80	< 0.50
MIC Ratio	> 0.80	0.45 < < 0.80	<0.45

In those cases, the second parameter will classify the gas and its group. The IEC provides a complete list of common substances with their own group and properties inside the IEC 600 79-12 (1978).



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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

Hazardous Area Classification

General Criteria:

The choice of classify an area is based on the assumption that flammable gas(es), vapor(s) or ignitible liquid(s) may be present. The choice starts from two basic assumption:

a) – There is an Hazardous Substance.

b) – There is a potential Source of Release.

Possible source of release include: vents, flanges, control valves, pump and compressor sealing, fittings, and floating roof seals. It is obvious that the presence of those elements inside a process plat is so spread and wide that usually not each of them must be considered during the area classification as a potential source of ignitible, o generally, hazardous substances. The following paragraphs will explain which of them are significant and have a relevance inside the classification study. Once that the substances are identified and the potential source localized, before the area classification, other factors must be taken in account like the grade of release, grade of ventilation and the topography of the plant.

Commonly, the grade or release is distinguished into three different category:

- *Continuous.*
- *Primary.*
- *Secondary*

Each of these categories leads naturally to one specific kind of location, but there is no firm rules (see Classification Precautions 9.10.VI). However the grade of release is strictly connected to the time of release:

Grade of Release	*Flammable Mixture time of release*
Continuous	*1000 or more Hours/year*
Primary	*10 < Hours/year < 1000*
Secondary	*10 < Hours/year*

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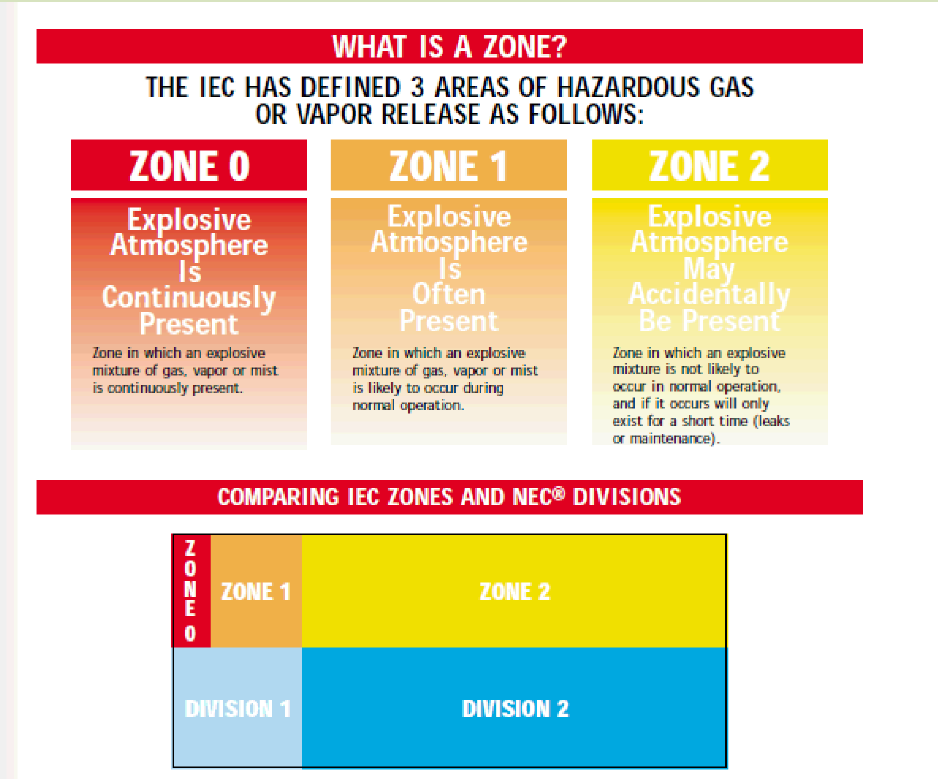
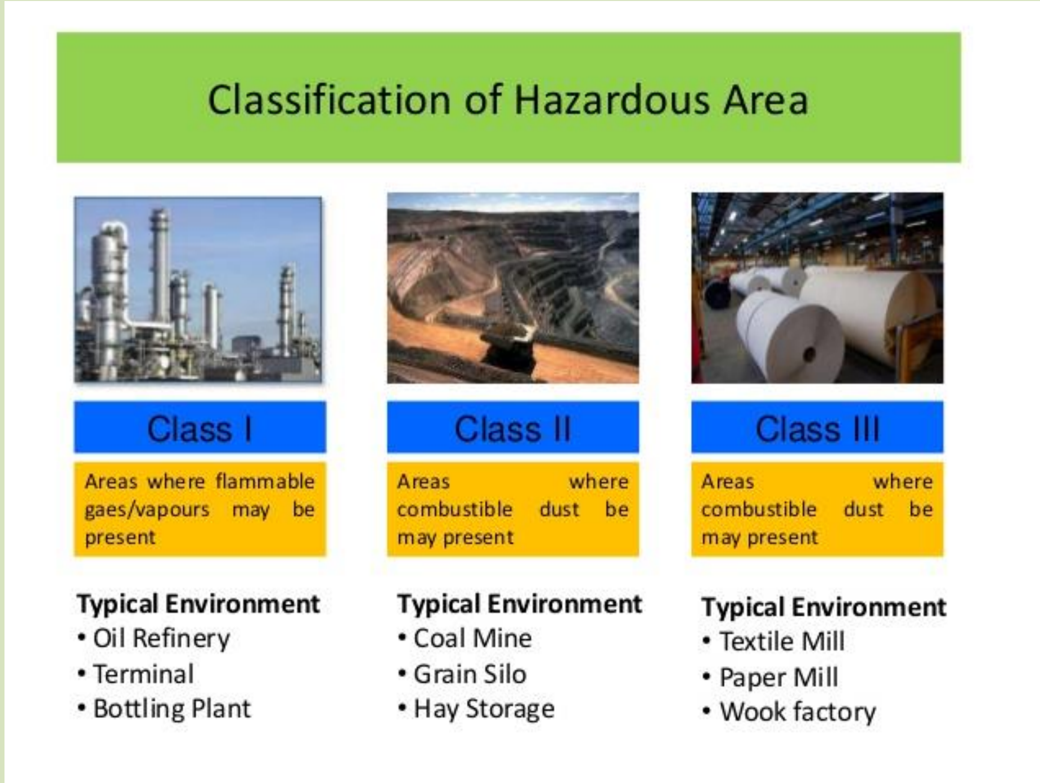
HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

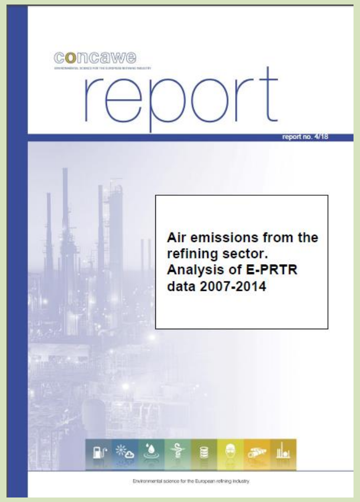
Once that the type of release has been indentified, the ventilation assessment of the specific area is required. The ventilation assessment is the last step to classify a specific area. To evaluate the extension of a specific area a great number of information must be gathered, especially:

- *Volatility of the flammable liquid*
- *Flash point*
- *Liquid Temperature at release*
- *LFL and UFL*
- *Vapor and liquid density*
- *Geometry of the source of release*
- *Quantity Released*
- *Potential Release Rate*
- *Concentration and starting conditions*
- *Ventilation*
- *Process Plant Topography*
- *Climatic Conditions*





Looking at the great number of information required, it is simply notice that have an accurate estimate of the hazardous area is really hard to get. Many codes and Recommended practice suggest several different examples and suggestions to achieve a correct safety levels, not underestimating the potential hazard (API RP 505 or NFPA 497).



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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

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Area Classification and Definition:

The area classification, especially the area definition, is the same for several different codes and standards like: API; IEC. NFPA. National Electrical Code (NFPA 70), etc.
The following paragraph is developed on the API RP 505 basis, and the area definition are reported from it.

Class I, Zone 0:

Class I, Zone 0 presents the following features:

(1) Is a location in which a presence of ignitible concentration, or flammable gases, or combustible liquids is continuous;
Or
(2) In which an ignitable concentration, or flammable gases, or combustible liquids is present for a long time.
This locations usually includes locations inside vented tanks or vessels containing volatile flammable liquids; the volume between the inner and the outer roof section of a floating roof tank containing volatile flammable liquids; inside open vessels, tanks and pits; and inside inadequately ventilated enclosures containing normally venting instruments utilizing or analyzing flammable fluids and venting the inside of enclosures.

Class I, Zone 1:

Class I, Zone 1 presents the following features:

(1) Is a location in which a presence of ignitible concentration, or flammable gases, or combustible liquids are likely to exist under normal operating conditions;
Or
(2) – in which an ignitible concentration, or flammable gases, or combustible liquids may exists frequently because of repair or repair maintenance operations or because of leakage;
Or
(3) In which equipment is operated or process carried on, of such nature that equipment breakdown or faulty operations could result in the release of ignitible concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become source of ignition.
Or
(4) Is adjacent to a Class I, Zone 0 location which ignitible concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation form sources of clean air and effective safeguards against ventilation failure has been taken.
This classification usually includes locations where flammable liquids or liquefied flammable gases are transferred from one container to another; inadequately ventilated pump rooms for flammable gas or for volatile flammable liquids; the interior of refrigerators and freezers in which volatile flammable materials are stored in the open, lightly stoppered, or easily ruptured containers; and other locations where ignitible concentrations of flammable vapors and gases are likely to occur in the course of normal operation but not classified as zone 0.

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Class I, Zone 2:

Class I, Zone 2 presents the following features:

(1) Is a location in which a presence of ignitible concentration, or flammable gases, or combustible liquids are not likely to occur under normal operating conditions and if the do occur will exists for a short period of time;

Or

(2) – in which an ignitible concentration, or flammable gases, or combustible liquids are handled ,loaded, unloaded, processed, or used, but in which the liquids, gases, or vapors normally are confined within closed containers of closed system from which they can escape ONLY as a result of accidental rupture or breakdown of the containers or system, or as result of the abnormal operation of the equipment with which the substances are handled or processed;

Or

(3) In which ignitible concentrations of flammable gases or vapors normally are prevented by positive mechanical ventilation, but which may become hazardous as a result of failure or abnormal operation of the ventilation equipment;

Or

(4) Is adjacent to a Class I, Zone 1 location which ignitible concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation form sources of clean air and effective safeguards against ventilation failure has been taken.

The zone 2 classification usually includes locations where volatile liquids, or flammable gases or vapors are used, but that would become hazardous only in case of an accident or of some unusual operating condition.

Zone Considerations:

The word "Normal" are commonly used inside the zone definitions, but is not synonymous of "everything is working properly". For instance, a process may be so sensitive to control that the activation of safety valves or other pressure relief equipment, o generally safety equipment, is frequently, and that should be considered "normal".

The frequency of the maintenance or repair is relevant to define the "normal" and "abnormal" situation: if the maintenance is required frequently the operations are to evaluate as "Normal", however if the maintenance frequency is low, its operations are included into the abnormal category.

Zone 1 location are usually placed as border line of each Zone 0 location; to separate Zone 0 and Zone 2 locations (Called "Transition zone(s)"). To prevent the extension of an Zone 1 location as border of the Zone 0 location, it can be used a vapor-tight barrier (see "definitions") to avoid the spreading of the hazardous substances.

Class I, Zone 2 locations are those area when abnormal conditions will generate a release. For instance, a leakage from a sealing is quite rare, and can be considered abnormal. Also the simultaneous rupture of the equipment and the electrical installation is quite rare.

Zone 2 location are usually placed as border line of each Zone 1 location (Called "Transition zone(s)"). To prevent the extension of an Zone 2 location as border of the Zone 1 location, it can be used a vapor-tight barrier (see "definitions") to avoid the spreading of the hazardous substances.

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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

The grade of release, and the kind of zone are not synonymous, in fact a continuous grade of release naturally leads to a constant presence of the flammable mixture in the area. But a specific assessment should be taken for each specific place.

Unclassified Zones:

Many process plant locations may remains unclassified at the end of the classification, why? Because the experience has shown that, regardless the grade of ventilation of the location, the likelihood of an accidental leakage and the consequent release of hazardous material are quite rare.
In those area category are included:

1) *Locations where flammable substances are contained in all-welded closed piping systems without valves, flanges or similar device.*
2) *Locations where flammable substances are contained in continuous metallic tubing without valves, flanges or similar device.*
3) *Adequate ventilated location surrounded by process items with continuous flame sources (e.g. flare tips)*
4) *Locations with any non-electric ignition sources (flare tips, free flame, etc) .*

Ventilation:

In the major part of the cases, the ventilation is one of the most important parameter for the classification of an area. Eventually gas or vapors leaked to the atmosphere can be diluted by dispersion or diffusion into the air dropping their concentration below the LFL concentration threshold. The ventilation, natural or artificial, leads to the continuous replacement of the air of a specific zone with "fresh air". The fresh air must come from an unclassified or Zone 2 location to be efficient and positive.
Suitable ventilation rates can also avoid persistence of an explosive gas atmosphere, thus influencing the type of zone (IEC 600 79-10. Mod.).
An "Adequate Ventilation" is defined as ventilation (natural or artificial) that is sufficient to prevent the accumulation of a concentration of flammable substances over the twenty-five percent (25%) of the concentration LFL threshold. Refer to NFPA 30 for additional details.

Ventilation Assessment:

The assessment of the ventilation system(s) can be done evaluating the hypothetical volume released and the time of residency of the same. The following analytical method is subject to several limitations, but adopting suitable safety factors, the error resulted is on the side of safety.
To start the assessment, it must be know the maximum release rate of the substance (G)
The first step is to evaluate the minimum volumetric flow of fresh air (Vair) needed to dilute the hazardous mixture:

Where:
k = 0.25 (Safety Factor) for primary and continuous grade of release, 0.50 for secondary grade of release.
LFL = Lower Flammable limit of the mixture
T = Ambient Temperature (in Kelvins)

Generally LFL are expressed as (Vol%), to convert it to (Kg/m3) use the following formula:

Where:
MW = Molecular Mass of the substance (Kg/mol).
Now we need to set the number of cycles of change, for the air, per time unit C (S-1), and the potential hazardous volume around the source can be estimated:

Where:
Vz = Potential Hazardous Volume near the release source (m3).
f = is an additional safety (and quality) factor equal to 1 ÷ 5 that denotes the quality of the ventilation system. The greatest value (5) means that the air flow is not fresh or is impeded.

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Once that Vz is estimated, it identify the volume within the ignitible mixture concentration is at least 25 or 50 % (related to the k value adopted) of its own LFL.

For an Enclosed Area (which 2/3 of the outside surface of the volume is covered) the number of cycles of changes of air per unit of time is defined by the following formula:

Vtot = is the total volume of the air flow rate.

Vo = is the total volume of the enclosed area.

In an open air situation, even with the lowest wind speed, the number of cycles of change air are high. Usually is adopted a C equal to 0.03 s-1 (related to a wind speed of 0.5 m/s). However, this method is quite conservative, over-sizing the hazardous area.

Once that the hazardous volume has been defined, the next step to estimate the grade of ventilation is to achieve the Persistence Time (t) of the flammable mixture. The time required for the average concentration to fall from the starting value of Xo to the LFL multiplied by k after the release has stopped can be estimated from:

t is estimated in the same time unit of C. A particular attention must be adopted for the Xo value: inside the hazardous volume, the concentration of the flammable substance vary sensibly between the 100% (in the whole area near the source of release) and the 25% of the LFL. However the proper value of Xo should be estimated for each case.

The residence time estimated, isn't a quantitative value for the area classification, it gives additional information about the abnormal process, and must be compared to the time scale of the specific process.An acceptable time of dispersion depends by the time and frequency of the release.

The volume Vz can be used to provide a means of rating the ventilation as: High, Medium, or low. The persistence time can be used to provide a means of rating the ventilation required to comply with the definition of Area 0, 1 or 2.

In particular ventilation can be rated as:

- *High – when Vz is small, almost negligible.*
- *Medium – when the Vz volume can be controlled.*
- *Low – when the Vz volume cannot be controlled.*

The code IEC 600 79-10 relate the value of Vz to the rate of the ventilation:

	Ventilation Rate		
	High	Medium	Low(2)
V_z (m3)	< 0.1	0.1 < V_z < V_o	> V_o

2) Low Ventilation cannot occur in open space cases.

With High Ventilation Grade, the ventilation is so efficient that the Hazardous volume can be considered negligible and the related area my remain unclassified. An high grade of Ventilation can be assigned only in cases of Artificial Ventilation, into small enclosed area.

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Another relevant parameter to consider is the "Ventilation availability". The availability needs to be taken into account during the area classification the type of zone. The level of availability are the following:

A – Good – Ventilation is present virtually continuously.
B – Fair – Ventilation is present during normal operation.
C – Poor – Doesn't met the feature of "good" and "Fair", but discontinuities are not to be expected to occur for long periods of time.

In open space cases, the wind action is included under the Good category even at the lowest speed (0.5 m/s). The effect of the ventilation to the area classification is summarized in the following table.

Grade of Release	Ventilation						
	Degree						
	High			Medium			Low
	Availability						
	Good	Fair	Poor	Good	Fair	Poor	Good, Fair, Low
Continuous	(Zone 0 NE)	(Zone 0 NE)	(Zone 0 NE)	Zone 0	Zone 0 +2	Zone 0 +1	Zone 0
Primary	(Zone 1 NE)	(Zone 1 NE)	(Zone 1 NE)	Zone 1	Zone 1 +2	Zone 1 +2	Zone 1 or 0
Secondary	(Zone 2 NE)	(Zone 2 NE)	Zone 2	Zone 2	Zone 1	Zone 2	Zone 1 and even 0

Grade of Release	Action to be taken with
Continuously	Summate all values for each source and use the result.
Primary	In accordance to the following table, summate the requisite number of the largest value of and apply the resulting total.
Secondary	Use only the largest volume of the sources of the same area.
NOTE: Differing grade of release are not required to be summated.	

The Zone definition NE indicates a theoretical zone that would be negligible extent under normal operating conditions. The symbol "+" adopted means "Surrounded by".

Multiple source:

An enclosed area, o in general, a specific zone could have several different release sources. How can I assess the ventilation? IEC 600 79-10   presents a simple method to evaluate the ventilation in a multi-source zone. The value of to adopt, during the calculation, depends from the grade of release. The following table shows the value to adopt for each grade of release category.

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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

STANDARDS

▪	**International**	**IEC 60 079 series**
▪	European	CENELEC 60 079 series
▪	National	USA : ANSI/API RP 505 (zone system)
		Russia : Gost R 51330-X-99 series

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Legislation, Standards and Technology

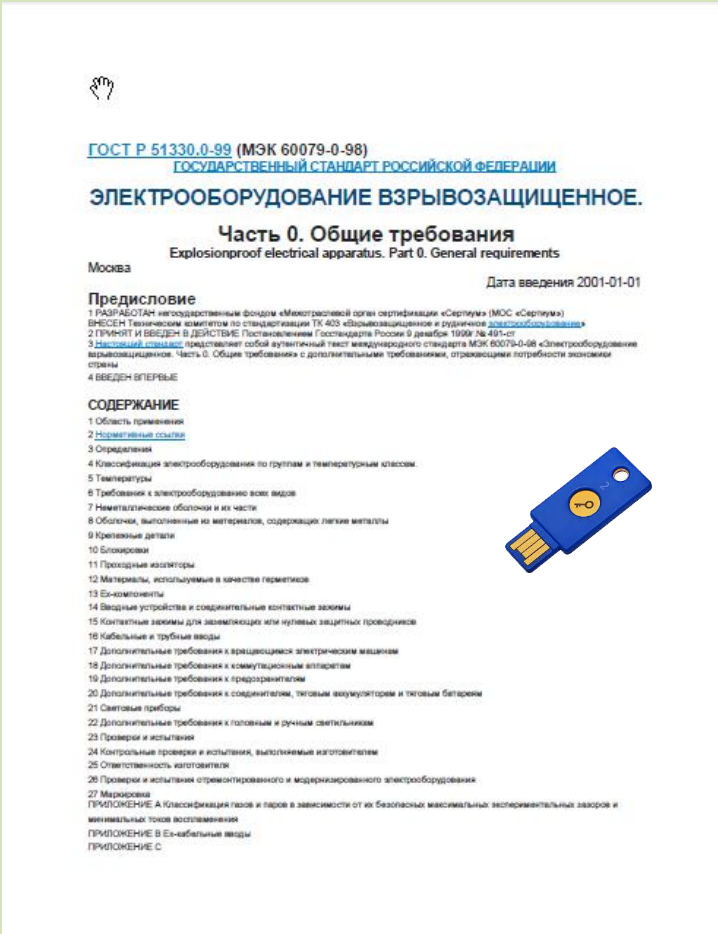
Explosion Protected Electrical Apparatus in the Russian Federation

Adaptations of National Standards to International Standards, deviations and peculiarities

by Vitaly Lipovsky

1. Status of application of explosion protected electrical apparatus in the Russian Federation

2. Harmonisation of Russian Standards with International Standards


ГОСТ Р 51330.0-99 (МЭК 60079-0-98)

ГОСУДАРСТВЕННЫЙ СТАНДАРТ РОССИЙСКОЙ ФЕДЕРАЦИИ

ЭЛЕКТРООБОРУДОВАНИЕ ВЗРЫВОЗАЩИЩЕННОЕ.

Часть 0. Общие требования

Explosionproof electrical apparatus. Part 0. General requirements

Москва

Дата введения 2001-01-01

Предисловие

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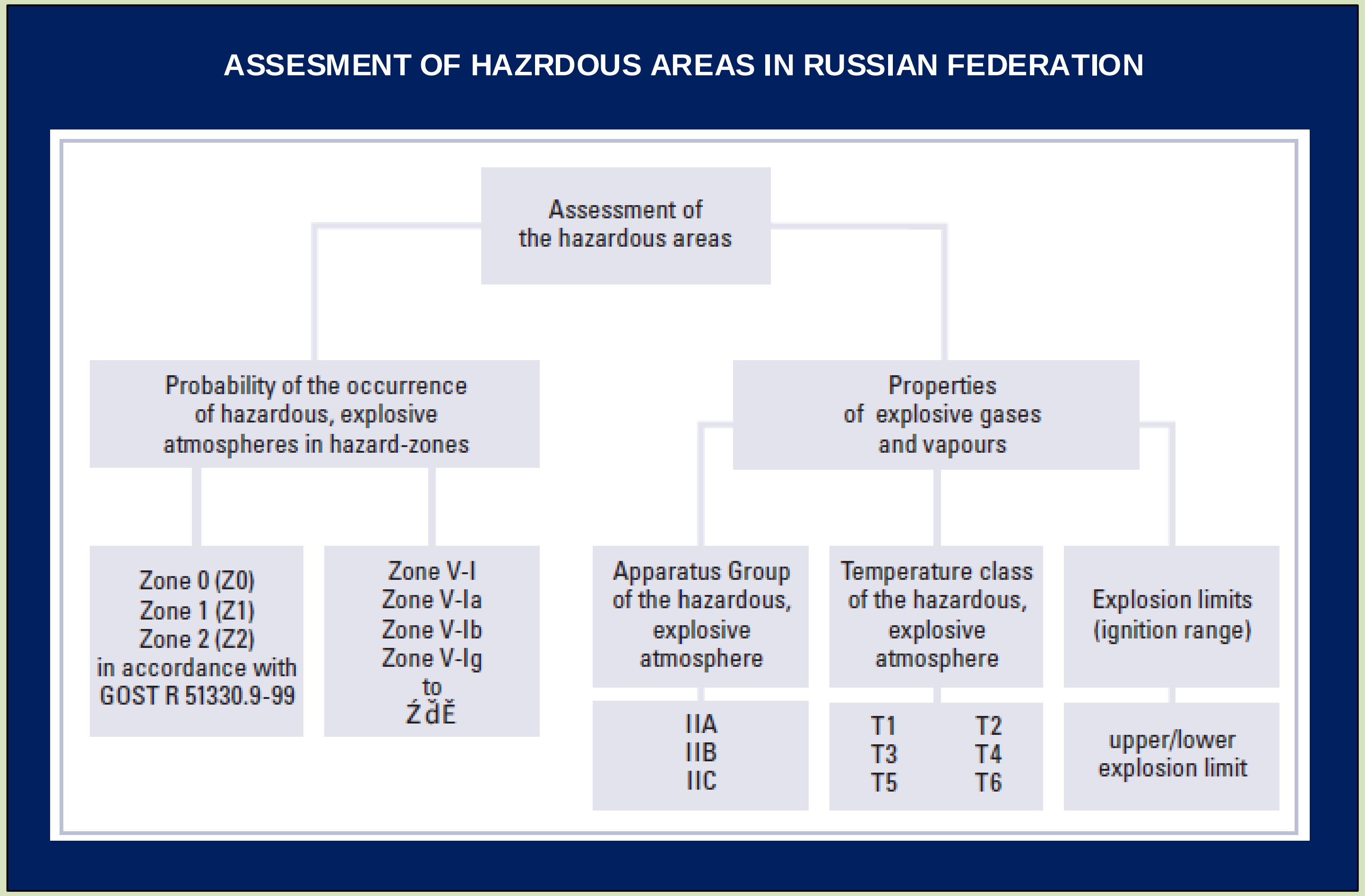

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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

An alternative method for the area Classification:

API RP 505 suggests an alternative method for the area classification. The method is based on the concept of "Point Source", involving the creation of specific boundaries for each individual source. At the end of the specific classification, an extended area classification is made by the composition of the adjacent different area.

The extent of the area is related to: 1) the grade and velocity of the release 2) and the volatility of the single substances. (the volatility of a mixture is equal to the highest volatility of its components).

The "Hazard Radius" is a direct function of volatility and rate of release, that means that as one of the last parameter is reduced, the extent of the hazardous area tend to be reduced.

The rate or the speed of the release (the quantity released) is divided into three different categories: High, Medium and Low.

A release with "High" speed flow has a greater hazard radius due to the misting transition. A mist, or spray, has usually a density lighter-than-air, that means that even at low wind speed the dispersion is quick and cover a wide area.

The second parameter adopted in this method is the substance volatility. The volatility of the most common flammable liquids and flammable gases or vapors, are present into "NFPA 30: Flammable and combustible liquid Code". The process groups all hazardous substances into five different "volatility categories".

Release Velocity		
Low	Medium	High
10 ft/s	10 < < 50 ft/s	50 ft/s
3 m/s	3 < < 15 m/s	15 m/s

Category G: *Flammable substances handled and processed as Gases and vapors.*

Category 1: *Materials, including LPGs, with a vapor pressure, at the operating temperature, above 70 psia (0.483 MPa). Those material, once released, vaporize in a very short time, even if processed liquefied.*

Category 2: *Materials are all Class 1A Flammable liquids with a vapor pressure of or less than 70 psia and all other flammable and combustible liquids with a vapor pressure between 14.7 psia and 70 psia at operating conditions.*

Category 3: *Materials are all Class 1B Flammable liquids with a vapor pressure of or less than 14.7 psia and all other flammable and combustible liquids with a vapor pressure less than 14.7 psia when the operating conditions are above their own flash point.*

Category 4: *Materials of Class II and heavier materials that are operated below their flash point*

For further information about the volatility, and flash point refer to NFPA 30, 325 and 497

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HAZARDOUS AREA CLASSIFICATION AND DEFINITIONS

Once that the material category has been found, its hazard radius is only function of the material release rate and the dispersion rate of gases and vapors.

Application to Non-Enclosed adequately ventilated locations containing Heavier-than-air gases or vapor:

The extent of the hazard radius, for each potential source, can be estimated by the following matrix. Those method, based on API RP experience, is usually adopted for those type of source usually not revised by the standards and codes.

For each substance category (G – 4), and for a specific rate of release, the radius can be estimated. The application of those radius shall be done with the following precautions. Where the extent of an hazard radius has been indentified, it must be revised by the good engineering safety judgment. The presence of physical barrier, inside the hazard radius estimated, shall be considered to modify the area extent. In many particular cases, the dispersion, especially for mixtures, must be evaluated using suitable software or models. In those cases, which the dispersion isn't subject at any external influence (e.g. Wind, Internal ventilation, etc.) the cloud dispersion is to be considered symmetric and uniformly.

	Hazard Radius		
Category 1	5-25	25-50	50-100
Category 2	3-5	5-25	25-50
Category 3	3	3-5	5-25
Category 4	n.a.	n.a.	n.a.
	Low < 10 Gal(US)/min	Medium 10 – 50 Gal(US)/min	High 50 – 100 Gal(US)/min
	Mass Release		

For example, a category 2 fluid, with a mass release of 13 gal(US)/min (0.82 litri/s), the hazard radius is estimated within the range of 5-25 ft (1.5 – 7.6 m), with an adequate knowledge of the source, and its area, the specific value can be estimated.

Fuel	Flash point	Autoignition temperature
Ethanol (70%)	16.6 °C (61.9 °F)[6]	363 °C (685 °F)[6]
Gasoline (petrol)	−43 °C (−45 °F)[7]	280 °C (536 °F)[8]
Diesel (2-D)	>52 °C (126 °F)[7]	210 °C (410 °F)[8]
Jet fuel (A/A-1)	>38 °C (100 °F)	210 °C (410 °F)
Kerosene	>38–72 °C (100–162 °F)	220 °C (428 °F)
Vegetable oil (canola)	327 °C (621 °F)	424 °C (795 °F)[9]
Biodiesel	>130 °C (266 °F)	

Flash Point Definition

Flash point is the lowest temperature at which a liquid can form an ignitable mixture in air near the surface of the liquid. The lower the flash point, the easier it is to ignite the material.
For example, gasoline has a flash point of approximately -40 degrees C (-40 F) and is more flammable than ethylene glycol (antifreeze) which has a flash point of 111 degrees C (232 F) in closed cup tests (see below).
A closely related and less common term is fire point, the temperature at which the flame becomes self-sustained so as to continue burning the liquid (at the flash point, the flame does not need to be sustained). The fire point is usually a few degrees above the flash point.

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ELECTRICAL EQUIPMENTS IN HAZARDOUS AREAS

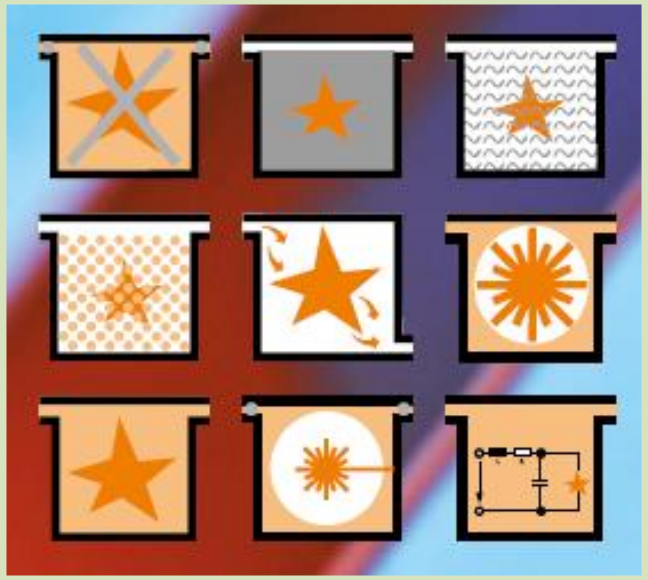
Ignition temperature

Gases/vapours temperature class

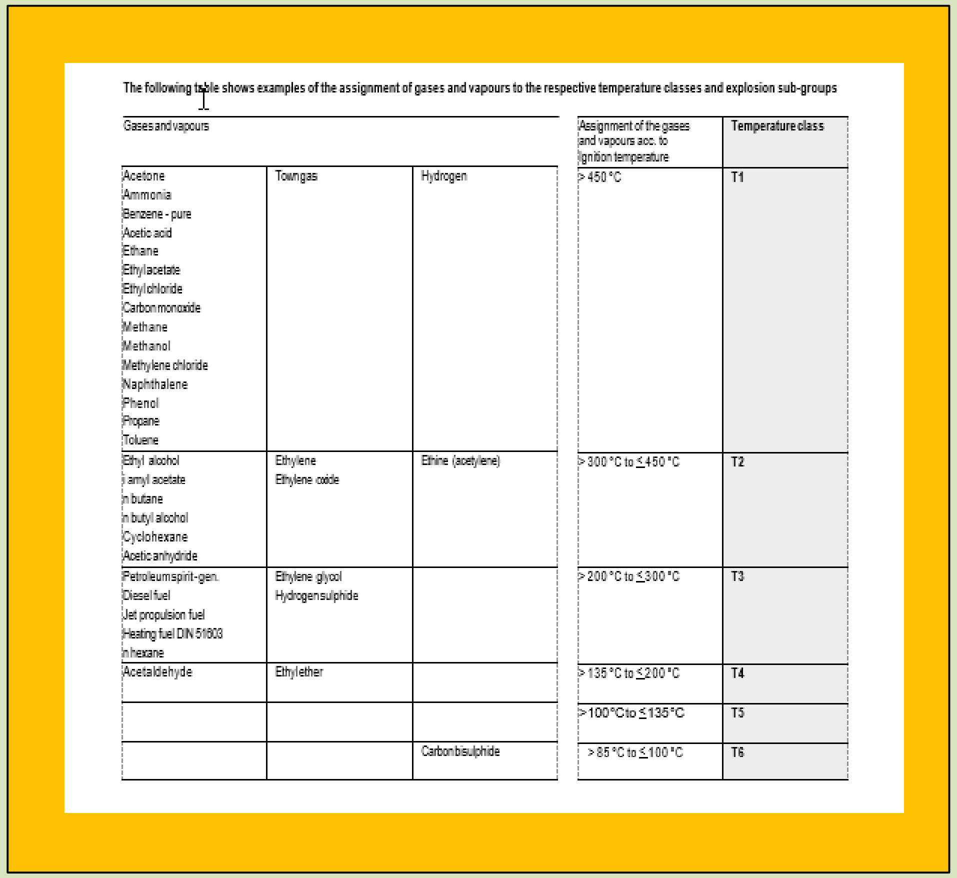
Many factors such as size, shape, type and surface quality have an influence on the ignition temperature. IEC, CENELEC and other standardisation committees have agreed on a method for gases and vapours defined in EN IEC 60079-20-1
„Method of test ignition temperature". This method is defined in such a way, that a value very close to the lowest practically possible, is determined.

By means of this method, gases and vapours are divided into temperature classes. According to these temperature classes, the surface temperatures in explosion protected equipment and other technological objects is designed in such a way that ignition by the surface is not possible. In the standard, permissible excess values and necessary safety margins below these standard values are defined in detail.

Temperature class	Max admissible surface temperatures on group II electrical apparatus	Ignition temperatures of inflammable substances in °C
T 1	450	> 450
T 2	300	> 300 ≤ 450
T 3	200	> 200 ≤ 300
T 4	135	> 135 ≤ 200
T 5	100	> 100 ≤ 135
T 6	85	> 85 ≤ 100



Groups		Gas	Ignition temperature (°C)	Temperature class					
				T1	T2	T3	T4	T5	T6
I		Methane	537	#					
II	A	Propane	465	#					
		Benzene	538	#					
		Ethyl nitrite	90						#
II	B	Ethylene	450	#					
		Diethyl-ether	180				#		
		Coal gas (town gas)	649	#					
II	C	Acetylene	337		#				
		Hydrogen	560	#					
		Carbon disulfide	100						#



The following table shows examples of the assignment of gases and vapours to the respective temperature classes and explosion sub-groups

Gases and vapours			Assignment of the gases and vapours acc. to ignition temperature	Temperature class
Acetone Ammonia Benzene - pure Acetic acid Ethane Ethylacetate Ethylchloride Carbon monoxide Methane Methanol Methylene chloride Naphthalene Phenol Propane Toluene	Towngas	Hydrogen	> 450 °C	T1
Ethyl alcohol i amyl acetate n butane n butyl alcohol Cyclohexane Acetic anhydride	Ethylene Ethylene oxide	Ethine (acetylene)	> 300 °C to ≤ 450 °C	T2
Petroleumspirit-gen. Diesel fuel Jet propulsion fuel Heating fuel DIN 51603 n hexane	Ethylene glycol Hydrogensulphide		> 200 °C to ≤ 300 °C	T3
Acetaldehyde	Ethylether		> 135 °C to ≤ 200 °C	T4
			> 100°C to ≤ 135 °C	T5
		Carbonbisulphide	> 85 °C to ≤ 100 °C	T6

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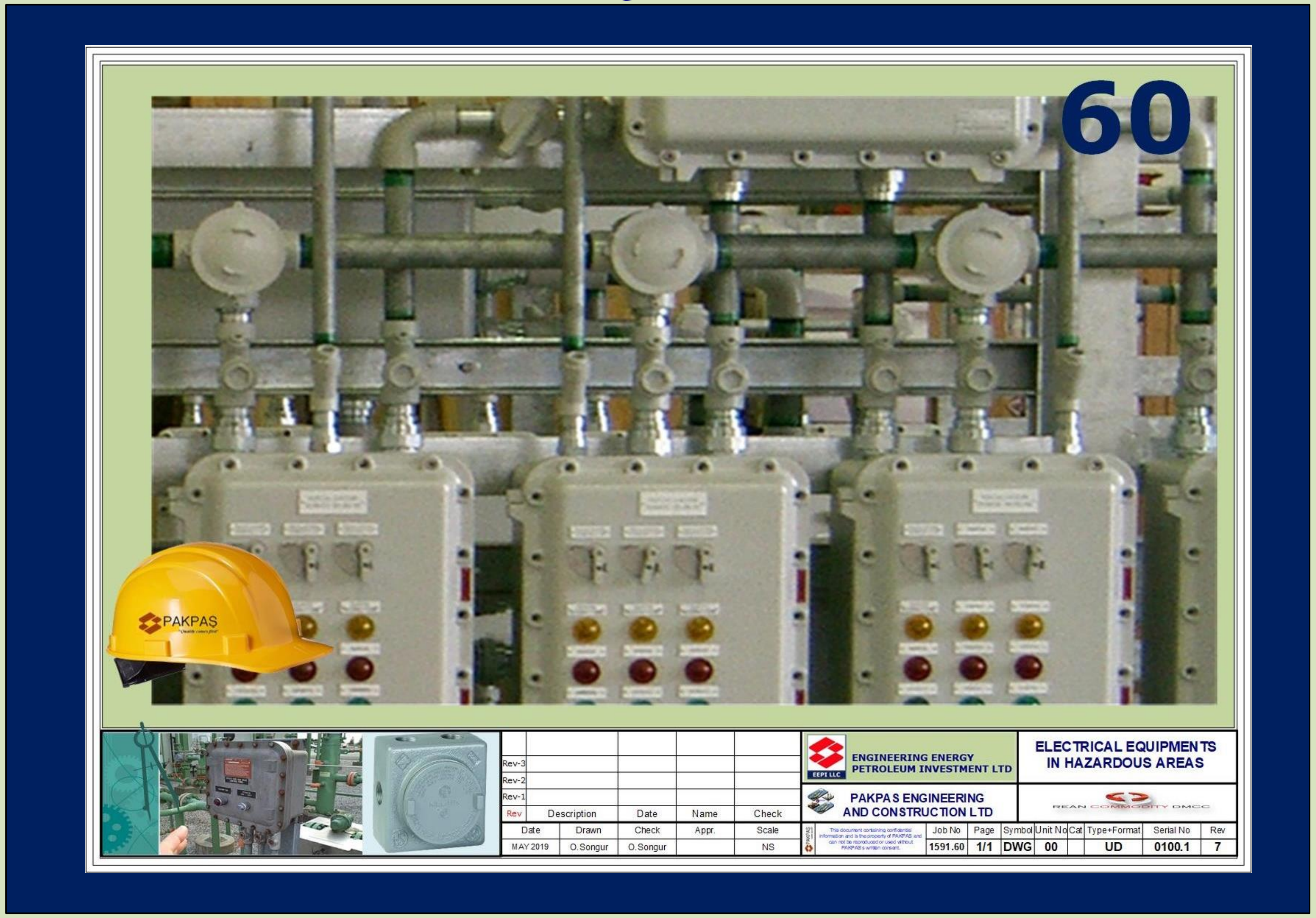
ELECTRICAL EQUIPMENTS IN HAZARDOUS AREAS

In electrical engineering, hazardous locations (sometimes abbreviated to HazLoc, pronounced Haz·Lōk) are defined as places where fire or explosion hazards may exist due to flammable gases, flammable liquid–produced vapors, combustible liquid–produced vapors, combustible dusts, or ignitable fibers/flyings present in the air in quantities sufficient to produce explosive or ignitable mixtures.[1] Electrical equipment that must be installed in such classified locations should be specially designed and tested to ensure it does not initiate an explosion, due to arcing contacts or high surface temperature of equipment.
The introduction of electrical apparatus for signaling or lighting in coal mines was accompanied by electrically-initiated explosions of flammable gas and dust. Technical standards were developed to identify the features of electrical apparatus that would prevent electrical initiation of explosions due to energy or thermal effects. Several physical methods of protection are used. The apparatus may be designed to prevent entry of flammable gas or dust into the interior. The apparatus may be strong enough to contain and cool any combustion gases produced internally. Or, electrical devices may be designed so that they cannot produce a spark strong enough or temperatures high enough to ignite a specified hazardous gas. Integrating these types of motors can ensure that equipment, facilities, and workers stay protected and machinery is not damaged.

Read BOOK-1591.60 ELECTRICAL EQUIPMENTS IN HAZARDOUS AREAS



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