

**AMERICAN NATIONAL STANDARD
ANSI/ISA-60079-10-1 (12.24.01)-2014**

**Explosive Atmospheres –
Part 10-1: Classification of areas
– Explosive gas atmospheres**

Approved 15 August 2014

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ANSI/ISA-60079-10-1(12.24.01)-2014

Explosive atmospheres - Part 10-1: Classification of areas – Explosive gas atmospheres

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Preface

This ISA standard is based on IEC Publication 60079-10-1, Edition 1. It is the intention of the ISA12 Committee to develop an ANSI standard that is harmonized with IEC 60079-10-1 to the fullest extent possible.

This preface, as well as all annexes, is included for informational purposes and is not part of ANSI/ISA-60079-10-1. The document is a modification of the IEC document and includes U.S. deviations encompassing both additions and deletions of information.

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INTRODUCTION

In areas where dangerous quantities and concentrations of flammable gas or vapor may arise, protective measures are to be applied in order to reduce the risk of explosions. This standard sets out the essential criteria against which the ignition hazards can be assessed, and gives guidance on the design and control parameters which can be used in order to reduce such a hazard.

This standard is a modification of IEC 60079-10-1 ed1.0 (2008-12), *Explosive Atmospheres - Part 10-1: Classification of Areas - Explosive Gas Atmospheres*, normalized as an American National Standard, with additional material added as appendices specifically for the classification of locations for electrical installations classified as Class I, Zone 0, Zone 1, or Zone 2 classification of hazardous areas. U.S. National Deviations are shown by strikeout through text deleted and underline under text added. There are six annexes in this standard. All annexes are informative and are not considered part of this standard.

Electrical installations in areas where flammable liquids or gases are produced, processed, stored or otherwise handled can be suitably designed if the locations of potential sources of release and accumulation are clearly defined. Once a location has been classified, requirements for electrical equipment and associated wiring should be determined from applicable publications. Applicable publications may include ANSI/NFPA 70 (NEC) or API RP 14FZ. Reference Section 2 for other possible applicable publications.

This first edition of ISA 60079-10-1 has been developed from ISA-TR12.24.01-1998 (IEC 79-10 Mod). This updated edition ~~and~~ now cancels and supersedes ~~ISA-TR12.24.01-1998 (IEC 79-10 Mod)~~ the first edition.

The significant changes with respect to ISA-TR12.24.01-1998 (IEC 79-10 Mod) are listed below:

- Introduction of the concept of change management as a means to document changes in the facility into Clause 4.2.
- Introduction of Clause A.3 (release rate) which gives thermodynamic equations for release rate with a number of examples for estimating release rate of fluids and gases.
- Introduction of Annex D which deals with explosion hazard from flammable mists generated by the release under pressure of high flash point liquids.
- Introduction of Annex E for Hydrogen.

Although the intended primary application of this standard is stated in its scope, it is important to note that it remains the responsibility of the users of the standard to judge its suitability for their particular purpose.

This standard was prepared by the International Society of Automation (ISA).

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EXPLOSIVE ATMOSPHERES –

Part 10-1: Classification of areas – Explosive gas atmospheres

1 Scope

This ~~part of IEC 60079 standard~~ is concerned with the classification of areas where flammable gas or vapor or mist hazards (see Notes 1, 2 and 3) may arise and may then be used as a basis to support the proper selection and installation of equipment for use in a hazardous area.

It is intended to be applied where there may be an ignition hazard due to the presence of flammable gas or vapor, mixed with air under normal atmospheric conditions (see Note 4), but it does not apply to

- a) mines susceptible to firedamp;
- b) the processing and manufacture of explosives;
- c) areas where a hazard may arise due to the presence of combustible dusts or fibres (refer to ~~IEC 61241-10 / IEC~~ ANSI/ISA-60079-10-2);
- d) catastrophic failures which are beyond the concept of abnormality dealt with in this standard (see Note 5);
- e) rooms used for medical purposes;
- f) domestic premises.

This standard does not take into account the effects of consequential damage.

Definitions and explanations of terms are given together with the main principles and procedures relating to hazardous area classification.

For detailed recommendations regarding the extent of the hazardous areas in specific industries or applications, reference may be made to national or industry codes relating to those applications.

NOTE 1 Flammable mists may form or be present at the same time as flammable vapors. Liquids not considered to be hazardous in terms of this standard (due to the flash point), when released under pressure may also generate flammable mists. In such cases, the strict application of area classification for gases and vapors may not be appropriate as the basis for selection of equipment.

Information on flammable mists is provided in Annex D.

NOTE 2 The use of IEC 60079-14 for selection of equipment and installations is not required for mist hazards. IEC 60079-14 has not been adopted for use in the US.

NOTE 3 For the purpose of this standard, an area is a three-dimensional region or space.

NOTE 4 Atmospheric conditions include variations above and below reference levels of 101,3 kPa (1 013 mbar) and 20 °C (293 K), provided that the variations have a negligible effect on the explosion properties of the flammable materials.

NOTE 5 Catastrophic failure in this context is applied, for example, to the rupture of a process vessel or pipeline and events that are not predictable.

NOTE 6 In any process ~~plant~~ facility, irrespective of size, there may be numerous sources of ignition apart from those associated with equipment. Appropriate precautions will be necessary to ensure safety in this context. This standard may be used with judgement for other ignition sources.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-426, *International Electrotechnical Vocabulary (IEV) – Part 426: Equipment for explosive atmospheres*

~~IEC-ANSI/ISA-60079-0, Explosive atmospheres – Part 0: Equipment – General requirements~~

~~IEC 60079-4, Electrical apparatus for explosive gas atmospheres – Part 4: Method of test for ignition temperature~~

~~IEC 60079-4A, First supplement to IEC 60079-4 (1966), Electrical apparatus for explosive gas atmospheres – Part 4: Method of test for ignition temperature~~

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

ISA-60079-20-1, Explosive atmospheres – Part 20-1: Material characteristics for gas and vapor classification - Test methods and data

ANSI/NFPA 497, Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas

ANSI/NFPA 70, National Electrical Code

29CFR, Code of Federal Regulations, Title 29, Labor

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ANSI/ISA-IEC-60079-0 and the following apply.

NOTE Additional definitions applicable to explosive atmospheres can be found in the IEC 60050-426.

3.1

explosive atmosphere

mixture with air, under atmospheric conditions, of flammable substances in the form of gas, vapor, dust, fibres, or flyings which, after ignition, permits self-sustaining propagation

[~~IEC~~ANSI/ISA-60079-0, definition 3.22]

3.2

explosive gas atmosphere

mixture with air, under atmospheric conditions, of flammable substances in the form of gas or vapor, which, after ignition, permits self-sustaining flame propagation

[~~IEC~~ANSI/ISA-60079-0, definition 3.24]

NOTE 1 Although a mixture which has a concentration above the upper explosive limit (UEL) is not an explosive gas atmosphere, it can readily become so and, in certain cases for area classification purposes, it is advisable to consider it as an explosive gas atmosphere.

NOTE 2 There are some gases which are explosive with the concentration of 100 %.

3.3

hazardous area (on account of explosive gas atmospheres)

an area in which an explosive gas atmosphere is or may be expected to be present, in quantities such as to require special precautions for the construction, installation and use of equipment

NOTE The National Electrical Code® defines hazardous areas as hazardous (classified) locations.

3.4

non-hazardous area (on account of explosive gas atmospheres)

~~an area in which an explosive gas atmosphere is not expected to be present in quantities such as to require special precautions for the construction, installation and use of equipment.~~

See 3.30

NOTE The National Electrical Code® does not define a non-hazardous areas but instead uses the term unclassified location.

3.5

zones

hazardous areas are classified into zones based upon the frequency of the occurrence and duration of an explosive gas atmosphere, or where adjacent to areas that are classified, as follows in 3.6, 3.7 and 3.8

3.6

Class I, Zone 0

~~an area in which an explosive gas atmosphere is present continuously or for long periods or frequently~~

a Class I, Zone 0 location is a location (1) in which ignitable concentrations of flammable gases or vapor are present continuously; or (2) in which ignitable concentrations of flammable gases or vapors are present for long periods of time

3.7

Class I, Zone 1

~~an area in which an explosive gas atmosphere is likely to occur in normal operation occasionally~~

a Class I, Zone 1 location is a location (1) in which ignitable concentrations of flammable gases or vapors are likely to exist under normal operating conditions; or (2) in which ignitable concentrations of flammable gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which equipment is operated or processes are carried on, of such a nature that equipment breakdown or faulty operations could result in the release of ignitable concentrations of flammable gases or vapors and also cause simultaneous failure of electrical equipment in a mode to cause the electrical equipment to become a source of ignition; or (4) that is adjacent to a Class I, Zone 0 location from which ignitable concentrations of vapors could be communicated, unless communication is prevented by adequate positive pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided

3.8

Class I, Zone 2

~~area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only~~

a Class I, Zone 2 location is a location (1) in which ignitable concentrations of flammable gases or vapors are not likely to occur in normal operation and, if they do occur, will exist only for a short period; or (2) in which volatile flammable liquids, flammable gases, or flammable vapors are handled, processed, or used but in which the liquids, gases, or vapors normally are confined within closed containers or closed systems from which they can escape, only as a result of accidental rupture or breakdown of the containers or system, or as a result of the abnormal operation of the equipment with which the liquids or gases are handled, processed, or used; or (3) in which ignitable 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) that is adjacent to a Class I, Zone 1 location, from which ignitable concentrations of flammable gases or vapors could be communicated, unless such communication is prevented by adequate positive-pressure ventilation from a source of clean air and effective safeguards against ventilation failure are provided.

~~[IEV 426-03-05]~~

~~NOTE Indications of the frequency of the occurrence and duration may be taken from codes relating to specific industries or applications.~~

3.9

source of release

a point or location from which a gas, vapor, mist or liquid may be released into the atmosphere so that an explosive gas atmosphere could be formed

IEV 426-03-06, modified

3.10

grades of release

there are three basic grades of release, as listed below in order of decreasing frequency and likelihood of the explosive gas atmosphere being present:

- a) continuous grade;
- b) primary grade;
- c) secondary grade.

A source of release may give rise to any one of these grades of release, or to a combination of more than one

3.11

continuous grade of release

release which is continuous or is expected to occur ~~frequently~~ or for long periods

3.12

primary grade of release

release which can be expected to occur periodically or occasionally during normal operation

3.13

secondary grade of release

release which is not expected to occur in normal operation and, if it does occur, is likely to do so only ~~infrequently~~ and for short periods

3.14

release rate

quantity of flammable gas, vapor or mist emitted per unit time from the source of release

3.15

normal operation

situation when the equipment is operating within its designed parameters

NOTE 1 Minor releases of flammable material may be part of normal operation. For example, releases from seals which rely on wetting by the fluid which is being pumped are considered to be minor releases.

NOTE 2 Failures (such as the breakdown of pump seals, flange gaskets or spillages caused by accidents) which involve urgent repair or shut-down are not considered to be part of normal operation nor are they considered to be catastrophic.

NOTE 3 Normal operation includes start-up and shut-down conditions of the facility.

3.16 ventilation

movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial means (for example, fans or extractors)

3.17 lower explosive limit (LEL)

concentration of flammable gas, vapor or mist in air below which an explosive gas atmosphere will not be formed

[IEV 426-02-09]

NOTE The term "LEL" and the term "LFL" are sometimes used interchangeably and are understood to be synonymous within the context of this document. For the purposes of area classification the lower value should be used. For example, the LEL for hydrogen is 9% yet the LFL is 4%.

3.18 upper explosive limit (UEL)

concentration of flammable gas, vapor or mist in air, above which an explosive gas atmosphere will not be formed

[IEV 426-02-10]

NOTE The term "UEL" and the term "UFL" are sometimes used interchangeably and are understood to be synonymous within the context of this document. For the purposes of area classification the higher value should be used. For example, the UEL for methane is 15% yet the UFL is 17%.

3.19 relative density of a gas or a vapor

density of a gas or a vapor relative to the density of air at the same pressure and at the same temperature (air is equal to 1,0)

3.20 flammable material (flammable substance)

material which is flammable of itself, or is capable of producing a flammable gas, vapor or mist

3.21 flammable liquid

liquid capable of producing a flammable vapor under any foreseeable operating conditions

NOTE An example of a foreseeable operating condition is one in which the flammable liquid is handled at temperatures close to or above its flash point.

3.22 flammable gas or vapor

gas or vapor which, when mixed with air in certain proportions, will form an explosive gas atmosphere

3.23 flammable mist

droplets of liquid, dispersed in air so as to form an explosive atmosphere

3.24 flashpoint

lowest liquid temperature at which, under certain standardized conditions, a liquid gives off vapors in a quantity such as to be capable of forming an ignitable vapor/air mixture

3.25 boiling point

temperature of a liquid boiling at an ambient pressure of 101,3 kPa (1 013 mbar)

NOTE The initial boiling point that should be used for liquid mixtures is to indicate the lowest value of the boiling point for the range of liquids present, as determined in a standard laboratory distillation without fractionation.

3.26

vapor pressure

pressure exerted when a solid or liquid is in equilibrium with its own vapor. It is a function of the substance and of the temperature

3.27

ignition temperature of an explosive gas atmosphere

lowest temperature of a heated surface which, under specified conditions according to ~~IEC 60079-4~~ ISA-60079-20-1, will ignite a flammable substance in the form of a gas or vapor mixture with air

[ANSI/ISA-~~IEC~~ 60079-0, ~~definition 3.26~~]

NOTE The term "ignition temperature" is understood to be the "autoignition temperature" within the context of this document.

3.28

extent of zone

distance in any direction from the source of release to the point where the gas/air mixture has been diluted by air to a value below the lower explosive limit

3.29

liquefied flammable gas

flammable material which is stored or handled as a liquid and which at ambient temperature and atmospheric pressure is a flammable gas

3.30

unclassified location

locations determined to be neither Class I, Zone 0; Class I, Zone 1; Class I, Zone 2; or any combination thereof

3.31

vapor tight barrier

a wall or other obstruction that will limit the passage of gas or vapor at atmospheric pressure, thus preventing the accumulation of vapor-air or gas-air mixtures in concentrations above 25% of their lower explosive limit.

4 General

4.1 Safety principles

Installations in which flammable materials are handled or stored should be designed, operated and maintained so that any releases of flammable material, and consequently the extent of hazardous areas, are kept to a minimum, whether in normal operation or otherwise, with regard to frequency, duration and quantity.

It is important to examine those parts of process equipment and systems from which release of flammable material may arise and to consider modifying the design to minimise the likelihood and frequency of such releases and the quantity and rate of release of material.

These fundamental considerations should be examined at an early stage of the design development of any process ~~plant~~ plant facility and should also receive prime attention in carrying out the area classification study.

In the case of activities other than those of normal operation, e.g. commissioning or maintenance, the area classification may not be valid. It is expected that this would be dealt with by a safe system of work.

In a situation in which there may be an explosive gas atmosphere, the following steps should be taken:

- a) eliminate the likelihood of an explosive gas atmosphere occurring around the source of ignition, or
- b) eliminate the source of ignition.

Where this is not possible, protective measures, process equipment, systems and procedures should be selected and prepared so the likelihood of the coincidence of a) and b) is so small as to be acceptable. Such measures may be used singly, if they are recognized as being highly reliable, or in combination to achieve the required level of safety.

4.2 Area classification objectives

Area classification is a method of analysing and classifying the environment where explosive gas atmospheres may occur so as to facilitate the proper selection and installation of equipment to be used safely in that environment. The classification also takes into account the ignition characteristics of the gas or vapor such as ignition energy (gas group, see Note 1) and ignition temperature (temperature class, see Note 2).

NOTE 1 ANSI/ISA-60079-10-1 is concerned with Gas Group II. Class I combustible materials are divided into Groups IIC, IIB, and IIA. These Gas Groups are defined in NFPA 497 and are extracted into NFPA 70, Article 505.

Group IIC. Atmospheres containing acetylene, hydrogen, or 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 gap (MESG) value less than or equal to 0.50 mm or minimum igniting current ratio (MIC ratio) less than or equal to 0.45.

Group IIB. Atmospheres containing acetaldehyde, ethylene, or flammable gas, flammable liquid produced vapor, or combustible liquid produced vapor mixed with air that may burn or explode, having either maximum experimental safe gap (MESG) values greater than 0.50 mm and less than or equal to 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.45 and less than or equal to 0.80.

Group IIA. Atmospheres containing acetone, ammonia, ethyl alcohol, gasoline, methane, propane, or 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 gap (MESG) value greater than 0.90 mm or minimum igniting current ratio (MIC ratio) greater than 0.80.

NOTE 2 Temperature class is a classification of the maximum surface temperature for Group II electrical equipment as shown below:

<u>Maximum surface temperature</u> <u>(°C)</u>	<u>Temperature class</u>
<u>450</u>	<u>T1</u>
<u>300</u>	<u>T2</u>
<u>200</u>	<u>T3</u>
<u>135</u>	<u>T4</u>
<u>100</u>	<u>T5</u>
<u>85</u>	<u>T6</u>

In most practical situations where flammable materials are used, it is difficult to ensure that an explosive gas atmosphere will never occur. It may also be difficult to ensure that equipment will never give rise to a source of ignition. Therefore, in situations where an explosive gas atmosphere has a high likelihood of occurring, reliance is placed on using equipment which has a low likelihood of creating a source of ignition. Conversely, where the likelihood of an explosive gas atmosphere occurring is reduced, equipment constructed with less rigorous requirements may be used.

~~Subsequent to the completion of the area classification, a risk assessment may be carried out to assess whether the consequences of ignition of an explosive atmosphere requires the use of equipment of a higher equipment protection level (EPL) or may justify the use of equipment with a lower equipment protection level than normally required. The EPL requirements may be recorded, as appropriate, on the area classification documents and drawings to allow proper selection of equipment.~~

It is rarely possible by a simple examination of a ~~plant facility~~ or ~~plant facility~~ design to decide which parts of the ~~plant facility~~ can be equated to the three zonal definitions (~~Class I~~, Zones 0, 1 and 2). A more detailed approach is therefore necessary and this involves the analysis of the basic possibility of an explosive gas atmosphere occurring.

The first step is to assess the likelihood of this, in accordance with the definitions of Class I, Zone 0, Zone 1 and Zone 2. Once the likely frequency and duration of release (and hence the grade of release), the release rate, concentration, velocity, ventilation and other factors which affect the type and/or extent of the zone have been determined, there is then a firm basis on which to determine the likely presence of an explosive gas atmosphere in the surrounding areas.

This approach therefore requires detailed consideration to be given to each item of process equipment which contains a flammable material, and which could therefore be a source of release.

In particular, Class I, Zone 0 or Zone 1 areas should be minimised in number and extent by design or suitable operating procedures. In other words, ~~plants facilities~~ and installations should be mainly Class I, Zone 2 or non-hazardous. Where release of flammable material is unavoidable, process equipment items should be limited to those which give secondary grade releases or, failing this (that is where primary or continuous grade releases are unavoidable), the releases should be of very limited quantity and rate. In carrying out area classification, these principles should receive prime consideration. Where necessary, the design, operation and location of process equipment should ensure that, even when it is operating abnormally, the amount of flammable material released into the atmosphere is minimised, so as to reduce the extent of the hazardous area.

Once a ~~plant facility~~ has been classified and all necessary records made, it is important that no modification to equipment or operating procedures is made ~~without discussion with those responsible for the area classification.~~ without a change management procedure to document and record changes to the facility and the subsequent review of the area classification. This Management of Change procedure should be consistent with the requirements of 29 CFR 1910.119. Unauthorised action may invalidate the area classification.

It is necessary to ensure that all equipment affecting the area classification which has been subjected to maintenance is carefully checked during and after re-assembly to ensure that the integrity of the original design, as it affects safety, has been maintained before it is returned to service.

NOTE 3 After the completion of the area classification, a risk assessment may be carried out to assess whether the consequences of ignition of an explosive atmosphere requires the use of equipment of a higher equipment protection level (EPL) or may justify the use of equipment with a lower equipment protection level than normally required. The EPL requirements may be recorded, as appropriate, on the area classification documents and drawings to allow proper selection of equipment. See 2014 NEC 505.8(l) or ANSI/ISA-TR12.13.03 as examples of this concept.

5 Area classification procedure

5.1 General

The area classification should be carried out by those who understand the relevance and significance of properties of flammable materials and those who are familiar with the process and

the equipment along with safety, electrical, mechanical and other qualified engineering personnel.

The following subclauses give guidance on the procedure for classifying areas in which there may be an explosive gas atmosphere. An example of a schematic approach to the classification of hazardous areas is given in Figure C.2.

The area classification should be carried out when the initial process and instrumentation line diagrams and initial layout plans are available and confirmed before ~~plant~~ facility start-up. Reviews should be carried out during the life of the ~~plant-facility~~.

5.2 Sources of release

The basic elements for establishing the hazardous zone types are the identification of the source of release and the determination of the grade of release.

Since an explosive gas atmosphere can exist only if a flammable gas or vapor is present with air, it is necessary to decide if any of these flammable materials can exist in the area concerned. Generally speaking, such gases and vapors (and flammable liquids and solids which may give rise to them) are contained within process equipment which may or may not be totally enclosed. It is necessary to identify where a flammable atmosphere can exist inside a process ~~plant-facility~~, or where a release of flammable materials can create a flammable atmosphere outside a process ~~plant-facility~~.

Each item of process equipment (for example, tank, pump, pipeline, vessel, etc.) should be considered as a potential source of release of flammable material. If the item cannot foreseeably contain flammable material, it will clearly not give rise to a hazardous area around it. The same will apply if the item contains a flammable material but cannot release it into the atmosphere (for example, an all-welded pipeline is not considered to be a source of release).

If it is established that the item may release flammable material into the atmosphere, it is necessary, first of all, to determine the grade of release in accordance with the definitions, by establishing the likely frequency and duration of the release. It should be recognized that the opening-up of parts of enclosed process systems (for example, during filter changing or batch filling) should also be considered as sources of release when developing the area classification. By means of this procedure, each release will be graded either 'continuous', 'primary' or 'secondary'.

Having established the grade of the release, it is necessary to determine the release rate and other factors which may influence the type and extent of the zone.

If the total quantity of flammable material available for release is "small", for example, laboratory use, whilst a potential hazard may exist, it may not be appropriate to use this area classification procedure. In such cases, account ~~shall~~should be taken of the particular risks involved.

The area classification of process equipment in which flammable material is burned, for example, fired heaters, furnaces, boilers, gas turbines etc., should take into account purge cycle, start-up and shut-down conditions.

Mists which can form through leaks of liquid can be flammable even though the liquid temperature is below the flash point. It is important therefore to ensure that clouds of mist do not occur (see Annex D).

NOTE While mists are identified as a form of hazard, the assessment criteria used in this standard for gases and vapors may not apply to mists.

5.3 Type of zone

The likelihood of the presence of an explosive gas atmosphere depends mainly on the grade of release and the ventilation. This is identified as a zone. Zones are recognized as: Class I, Zone 0, Zone 1, Zone 2 and the non-hazardous area.

NOTE 1 A continuous grade of release normally leads to a Class I, Zone 0, a primary grade to Class I, Zone 1 and a secondary grade to Class I, Zone 2 (see Annex B).

NOTE 2 Where zones created by adjacent sources of release overlap and are of different zonal classification, the higher classification criteria will apply in the area of overlap. Where overlapping zones are of the same classification, this common classification will normally apply.

5.4 Extent of zone

The extent of the zone depends on the estimated or calculated distance over which an explosive atmosphere exists before it disperses to a concentration in air below its lower explosive limit with an appropriate safety factor. When assessing the area of spread of gas or vapor before dilution to below its lower explosive limit, expert advice should be sought.

Consideration should always be given to the possibility that a gas which is heavier than air may flow into areas below ground level (for example, pits or depressions) and that a gas which is lighter than air may be retained at high level (for example, in a roof space).

Where the source of release is situated outside an area or in an adjoining area, the penetration of a significant quantity of flammable gas or vapor into the area can be prevented by suitable means such as:

- a) physical barriers;
- b) maintaining a sufficient overpressure in the area relative to the adjacent hazardous areas, so preventing the ingress of the explosive gas atmosphere;
- c) purging the area with sufficient flow of fresh air, so ensuring that the air escapes from all openings where the flammable gas or vapor may enter.

The extent of the zone is mainly affected by the following chemical and physical parameters, some of which are intrinsic properties of the flammable material; others are specific to the process. For simplicity, the effect of each parameter listed below assumes that the other parameters remain unchanged.

5.4.1 Release rate of gas or vapor

The greater the release rate, the larger the extent of the zone. The release rate depends itself on other parameters, namely

- a) Geometry of the source of release

This is related to the physical characteristics of the source of release, for example, an open surface, leaking flange, etc. (see Annex A).

- b) Release velocity

For a given source of release, the release rate increases with the release velocity. In the case of a product contained within process equipment, the release velocity is related to the process pressure and the geometry of the source of release. The size of a cloud of flammable gas or vapor is determined by the rate of flammable vapor release and the rate of dispersion. Gas and vapor flowing from a leak at high velocity will develop a cone-shaped jet which will entrain air and be self-diluting. The extent of the explosive gas atmosphere will be almost independent of air flow. If the material is released at low velocity or if its velocity is reduced by impingement on a solid object, it will be carried by the air flow and its dilution and extent will depend on air flow.

- c) Concentration

The release rate increases with the concentration of flammable vapor or gas in the released mixture.

d) Volatility of a flammable liquid

This is related principally to the vapor pressure, and the enthalpy ("heat") of vaporization. If the vapor pressure is not known, the boiling point and flashpoint can be used as a guide.

An explosive gas atmosphere cannot exist if the flashpoint is above the relevant maximum temperature of the flammable liquid. The lower the flashpoint, the greater may be the extent of the zone. However, if a flammable material is released in a way that forms a mist (for example, by spraying) an explosive atmosphere may be formed below the flashpoint of the material.

NOTE 1 Flashpoints of flammable liquids are not precise physical quantities, particularly where mixtures are involved.

NOTE 2 Some liquids (for example, certain halogenated hydrocarbons) do not possess a flashpoint although they are capable of producing an explosive gas atmosphere. In these cases, the equilibrium liquid temperature which corresponds to the saturated concentration at the lower explosive limit should be compared with the relevant maximum liquid temperature.

e) Liquid temperature

The vapor pressure increases with temperature, thus increasing the release rate due to evaporation.

NOTE The temperature of the liquid after it has been released may be increased, for example, by a hot surface or by a high ambient temperature.

5.4.2 Lower explosive limit (LEL)

For a given release volume, the lower the LEL the greater will be the extent of the zone.

NOTE Experience has shown that a release of ammonia, with an LEL of 15 % by volume, will often dissipate rapidly in the open air, so an explosive gas atmosphere will, in most cases be of negligible extent.

5.4.3 Ventilation

With increased ventilation, the extent of the zone will normally be reduced. Obstacles which impede the ventilation may increase the extent of the zone. On the other hand, some obstacles, for example, dykes, walls or ceilings, may limit the extent.

NOTE 1 A shelter with a large roof-ventilator and with the sides open sufficient to allow free passage of air through all parts of the building in many cases is considered well ventilated and should be treated as an open air area (i.e. "medium" degree and "good" availability).

NOTE 2 Increased air movement may also increase the rate of release of vapor due to increased evaporation on open liquid surfaces.

5.4.4 Relative density of the gas or vapor when it is released

If the gas or vapor is significantly lighter than air, it will tend to move upwards. If significantly heavier, it will tend to accumulate at ground level. The horizontal extent of the zone at ground level will increase with increasing relative density and the vertical extent above the source will increase with decreasing relative density.

NOTE 1 For practical applications, a gas or vapor which has a relative density below 0,8 is regarded as being lighter than air. If the relative density is above 1,2 it is regarded as being heavier than air. Between these values, both of these possibilities should be considered.

NOTE 2 With gases or vapors lighter than air, an escape at low velocity will disperse fairly rapidly upwards; the presence of a roof will, however, inevitably increase the area of spread under it. If the escape is at high velocity in a free jet the action of the jet, although entraining air which dilutes the gas or vapor, may increase the distance over which the gas/air mixture remains above its LEL. For gases that are lighter than air, a release at high pressure may cool the gas thus increasing relative density. The release may initially behave as heavier than air until normal buoyancy is returned.

NOTE 3 With gases or vapors heavier than air, an escape at low velocity will tend to flow downward and may travel long distances over the ground before it is safely dispersed by atmospheric diffusion. Special regard therefore needs to be paid to the topography of any site under consideration and also to surrounding areas in order to determine where gases or vapors might collect in hollows or run down inclines to lower levels. If the escape is at high velocity in a free jet the jet-mixing action by entraining air may well reduce the gas/air mixture to below its LEL in a much shorter distance than in the case of a low-velocity escape.

NOTE 4 Care needs to be taken when classifying areas containing cryogenic flammable gases such as liquefied natural gas. Vapors emitted can be heavier than air at low temperatures and become lighter than air on approaching ambient temperature.

5.4.5 Other parameters to be considered

a) Climatic conditions

The rate of gas or vapor dispersion in the atmosphere increases with wind speed but there is a minimum speed of 2 m/s – 3 m/s required to initiate turbulent diffusion; below this, layering of the gas or vapor occurs and the distance for safe dispersal is greatly increased. In ~~plant~~ areas sheltered by large vessels and structures, the speed of air movement may be substantially below that of the wind; however, obstruction of air movement by items of equipment tends to maintain turbulence even at low wind speeds.

NOTE 1 In Annex B (Clause B.4), 0,5 m/s wind speed is considered to be appropriate for determining the rates at which ventilation in an outdoor situation dilutes a flammable release. This lower value of wind speed is appropriate for that purpose, in order to maintain a conservative approach, even though it is recognized that the tendency of layering may compromise the calculation.

NOTE 2 In normal practice, the tendency of layering is not taken into account in area classification because the conditions which give rise to this tendency are rare and occur for short periods only. However, if prolonged periods of low wind speed are expected for the specific circumstance then the extent of the zone should take account of the additional distance required to achieve dispersion.

b) Topography

Some liquids are less dense than water and do not readily mix with water: such liquids can spread on the surface of water (whether it be on the ground, in ~~plant~~plant facility drains or in pipe trenches) and then be ignited at a point remote from the original spillage, therefore putting at risk a large area of ~~plant~~plant facility.

The layout of the ~~plant~~plant facility, where possible, should be designed to aid the rapid dispersal of explosive gas atmospheres. An area with restricted ventilation (for example, in pits or trenches) that would otherwise be Class I, Zone 2 may require Class I, Zone 1 classification; on the other hand, wide shallow depressions used for pumping complexes or pipe reservations may not require such rigorous treatment.

5.4.6 Illustrative examples

Annex C provides examples to illustrate the principles of hazardous area classification.

Factors which may affect the rate of release and hence the extent of zones are illustrated for the scenarios below:

a) Source of release: open surface of liquid

In most cases, the liquid temperature will be below the boiling point and the vapor release rate will depend principally on the following parameters:

- liquid temperature;
- vapor pressure of the liquid at its surface temperature;
- dimensions of the evaporation surface;
- ventilation and air movement.

b) Source of release: virtually instantaneous evaporation of a liquid (for example, from a jet or spray)

Since the discharged liquid vaporizes virtually instantaneously, the vapor release rate is equal to the liquid flow rate and this depends on the following parameters:

- liquid pressure;
- geometry of the source of release.

Where the liquid is not instantaneously vaporized, the situation is complex because droplets, liquid jets and pools may create separate sources of release.

c) Source of release: leakage of a gas mixture

The gas release rate is affected by the following parameters:

- pressure within the equipment which contains the gas;
- molecular mass;
- geometry of the source of release;
- concentration of flammable gas in the released mixture.

For examples of sources of release and release rates, see Annex A.

6 Ventilation

6.1 General

Gas or vapor released into the atmosphere can be diluted by dispersion or diffusion into the air until its concentration is below the lower explosive limit. Ventilation, i.e. air movement leading to replacement of the atmosphere in a volume around the source of release by fresh air, will promote dispersion. Suitable ventilation rates can also avoid persistence of an explosive gas atmosphere thus influencing the type of zone.

6.2 Main types of ventilation

Ventilation can be accomplished by the movement of air due to the wind and/or by temperature gradients or by artificial means such as fans. So two main types of ventilation are thus recognized:

- a) natural ventilation;
- b) artificial ventilation, general or local.

6.3 Degree of ventilation

The most important factor is that the degree or amount of ventilation is directly related to the types of sources of release and their corresponding release rates. This is irrespective of the type of ventilation, whether it be wind speed or the number of air changes per time unit. Thus optimal ventilation conditions in the hazardous area can be achieved, and the higher the amount of ventilation in respect of the possible release rates, the smaller will be the extent of the zones (hazardous areas), in some cases reducing them to a negligible extent (non-hazardous area).

Practical examples for guidance on the degree of ventilation which may be used are given in Annex B.

6.4 Availability of ventilation

The availability of ventilation has an influence on the presence or formation of an explosive gas atmosphere and thus also on the type of zone. As availability, or reliability, of the ventilation decreases the type of zone is normally increased. Guidance on availability is given in Annex B.

NOTE Combining the concepts of degree of ventilation and level of availability results in a quantitative method for the evaluation of zone type (see Annex B).

7 Documentation

7.1 General

It is recommended that area classification is undertaken in such a way that the various steps which lead to the final area classification are properly documented.

All relevant information used should be referred to. Examples of such information, or of a method used, would be:

- a) recommendations from relevant recommended practices, codes and standards;
- b) gas and vapor dispersion characteristics and calculations;
- c) a study of ventilation characteristics in relation to flammable material release parameters so that the effectiveness of the ventilation can be evaluated.

Those properties which are relevant to area classification of all process materials used on the ~~plant~~ plant-facility should be listed. These may include molecular mass, flash point, boiling point, ignition temperature, vapor pressure, vapor density, explosive limits, gas group and temperature class (~~IEC 60079-20~~ ISA-60079-20-1 and ANSI/NFPA 497). A suggested format for the materials listing is given in Table C.1.

The results of the area classification study and any subsequent alterations to it ~~shall~~ should be placed on record. A suggested format is given in Table C.2.

7.2 Drawings, data sheets and tables

Area classification documents may be in hard copy or electronic form and should include plans and elevations or three dimensional models, as appropriate, which show both the type and extent of zones, gas group, ignition temperature and/or temperature class.

Where the topography of an area influences the extent of the zones, this should be documented.

The documents should also include other relevant information such as

- a) The location and identification of sources of release. For large and complex ~~plants~~ plants-facilities or process areas, it may be helpful to itemize or number the sources of release so as to facilitate cross-referencing between the area classification data sheets and the drawings;
- b) The position of openings in buildings (for example, doors, windows and inlets and outlets of air for ventilation).
- c) Identification of the basis that determined the extent of the classified areas including the methodology applied, such as pressurization, ventilation, and vapor tight barriers.

The area classification symbols which are shown in Figure C.1 are the preferred ones. A symbol key ~~shall~~ should always be provided on each drawing. Different symbols may be necessary where multiple equipment groups and/or temperature classes are required within the same type of zone (for example, Class I, Zone 2 IIC T1 and Class I, Zone 2 IIA T3).