CLASSIFICATION OF AREAS
FOR
ELECTRICAL INSTALLATIONS AT
HYDROCARBON PROCESSING AND HANDLING FACILITIES

OISD-STANDARD-113
Revised Edition, October 2013

Oil Industry Safety Directorate
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CLASSIFICATION OF AREAS
FOR
ELECTRICAL INSTALLATIONS AT
HYDROCARBON PROCESSING AND HANDLING FACILITIES

Prepared by:
COMMITTEE ON
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Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director
Oil Industry Safety Directorate
FOREWORD

The Oil industry in India is more than 100 years old. Because of various collaboration agreements, a variety of international codes and standards have been in vogue. Standardisation in design philosophies, operating and maintenance practices at a national level was hardly in existence. This coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state-of-the-art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self-regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly OISD constituted a number of committees of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on “Classification of Areas for Electrical Installations at Hydrocarbon Processing and Handling Facilities” was prepared by the committee on Classification of Areas for Electrical Installations. This document is based on the accumulated knowledge and experience of industry members and the various national and international codes and practices. It is hoped that the provision of this document, if implemented objectively, may go a long way to improve the safety and reduce accidents in Hydrocarbon Processing & Handling Facilities. Suggestions for amendments to this document should be addressed to:

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These documents are intended only to supplement and not to replace the prevailing statutory requirements.
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CLASSIFICATION OF AREAS FOR ELECTRICAL INSTALLATIONS

1.0 INTRODUCTION

1.1 BACKGROUND

With the rapid growth of the petroleum industry, the risk associated with the processing, handling & storage of highly flammable gases, vapours & liquids has increased tremendously. It is often necessary to use electricity in some form or the other in such high risk locations and consequently the need to assess and classify these hazardous areas assume great importance. When the electrical equipment/ instruments/ apparatus/ fittings is to be installed in or around a hazardous area, it is frequently possible by taking care in the layout of the installations to locate much of the equipment in less hazardous or non-hazardous area and thus reduce the number of special equipment required. Alternatively, they should be designed, installed and maintained in accordance with measures recommended for the area in which the apparatus is located.

1.2 NEED FOR AREA CLASSIFICATION

Hazardous areas are classified to assist selection of electrical equipment which will be safe as well as cost effective. While classifying an area the probability of release of flammable liquids or vapours or mist in sufficient quantity to constitute an explosive or ignitable mixture must be considered. The question of whether such release is likely to occur during normal operation, or only as a result of an unusual occurrence or abnormal conditions, must also be determined.

2.0 SCOPE

This standard is applicable to classification of hazardous areas for electrical installations in onshore processing, storage and transportation facilities handling flammable liquids, vapours or gases. For the purpose of this standard an area is a three dimensional region or space. The zoning considers only the probability of occurrence of an explosive atmosphere, its extent and duration. It does not consider the consequential effects of ignition having taken place or of the environment.

This standard does not cover offshore installations and also the provisions of this standard do not apply to the following:
1. Onshore Drilling and Work over rigs.
2. E&P onshore Production installations
   • Group Gathering Stations (GGS)/ Oil Collecting stations (OCS),
   • Gas Compression plant (GCP)/ Gas Compression Station (GCS),
   • Early Production Set up (EPS),
   • Quick Production Set up (QPS)/ Well Head Installations (WHI).
3. Dusts and fibres in suspension in air.
5. Catastrophic failures that are beyond the concept of abnormality in this standard.

In any installation irrespective of size there may be numerous sources of ignition apart from those associated with electrical sources. Precautions may be necessary to ensure safety but guidance in this aspect is outside the scope of this standard.

This Standard is intended to be applied where there may be an ignition hazard due to presence of flammable gas or vapour mixed with air under normal atmospheric conditions.

Note: This Standard is concerned with the classification of area where inflammable gas or vapour or mist hazards may arise and may then be used as a basis to support the proper selection and installation of equipment for use in hazardous area.
3.0 DEFINITIONS/ TERMINOLOGY

3.1 ADEQUATE VENTILATION
Adequate ventilation is defined as ventilation (Natural or artificial) which is sufficient to prevent the accumulations of significant quantities of gas-air mixtures in concentration above 25% of their Lower Explosive (Flammable) Limit (LEL).

3.2 BOILING POINT
The temperature of a liquid boiling at an ambient pressure of 101.3 kPa (1013 mbar).
NOTE — For liquid mixtures the initial boiling point should be used. 'Initial boiling point' is used for liquid mixtures to indicate the lowest value of the boiling point for the range of liquids present.

3.3 CRYOGENIC LIQUIDS
Cryogenic liquids are liquefied gases that are kept in their liquid state at sub-zero temperature.

3.4 EXPLOSIVE GAS ATMOSPHERE
A mixture with air, under normal atmospheric conditions, of flammable materials in the form of gas, vapour, or mist, in which, after ignition, combustion spreads throughout the unconsumed mixture.

NOTES
1. This definition specifically excludes dusts and fibres in suspension in air.
2. Although a mixture which has a concentration above the upper explosive limit (UEL) is not an explosive gas atmosphere, however for area classification purposes it is advisable to consider it as an explosive gas atmosphere.

3.5 EXPLOSIVE LIMITS

3.5.1 Lower Explosive Limit (LEL) - The concentration of flammable gas, vapour or mist in air, below which an explosive gas atmosphere will not be formed.

3.5.2 Upper Explosive Limit (UEL) - The concentration of flammable gas, vapour or mist in air, above which an explosive gas atmosphere will not be formed.

3.6 FLASH POINT
The minimum temperature at which the liquid gives so much vapour that this vapour, when mixed with air, forms an ignitable mixture and gives a momentary flash on application of a small pilot flame under specified conditions of test.

3.7 FLAMMABLE SUBSTANCE

3.7.1 Flammable Gas or Vapour - Gas or vapour which, when mixed with air in certain proportions, will form an explosive gas atmosphere.

3.7.2 Flammable Liquid - A liquid capable of producing a flammable vapour or mist under any foreseeable operating conditions.

3.7.3 Flammable Mist - Droplets of flammable liquid, dispersed in air, so as to form an explosive atmosphere.

3.8 HAZARDOUS (FLAMMABLE) ATMOSPHERE
An atmosphere containing any flammable gas or vapour in a concentration capable of ignition.

3.9 HAZARDOUS AREA
An area shall be deemed to be a hazardous area, where
(i) Petroleum having flash point below 65°C or any flammable gas or vapour in a concentration capable of ignition is likely to be present.
(ii) Petroleum or any flammable liquid having flash point above 65°C is likely to be refined, blended, handled or stored at or above its flash point.

3.10 IGNITION SOURCE
Source of ignition is any electrical installation operating at energy levels sufficient to release incendiary energy.
Note: In any installation irrespective of size there may be numerous sources of ignition apart from those associated with electrical sources. Precautions may be necessary to ensure safety but guidance in this aspect is outside the scope of this standard.

3.11 IGNITION TEMPERATURE
The lowest temperature at which ignition occurs in a mixture of explosive gas and air when the method of testing ignition temperatures specified in relevant Indian Standard is followed.

3.12 INTRINSIC SAFETY
Type of protection based on the restriction of electrical energy within apparatus and of interconnecting wiring exposed to the potentially explosive atmosphere to a level incapable to cause ignition by either sparking or heating effects.

3.13 NON-HAZARDOUS AREA
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 electrical apparatus.

3.14 NORMAL OPERATION
The situation when the plant equipment is operating within its design parameters. Normal operation includes start-up and shut-down conditions.

3.15 SOURCE OF RELEASE
A source of release is a point or location from which minor releases of flammable vapours, gases, or mist may take place into the atmosphere so that a hazardous atmosphere could be formed.

3.16 PROTECTED FIRED VESSEL
Any fired vessel that is provided with equipment, such as flame arrestors, stack temperatures shutdowns, forced draft burners with safety controls and spark arrestors, designed to eliminate the air intake and exhaust as sources of ignition.

3.17 PRESSURISED ROOM
A room which has been made safe by pressurizing or purging with a plenum of safe atmosphere by keeping minimum 25 Pa (0.25 mbar) more pressure than that of surrounding atmosphere with all doors and windows closed.

3.18 RELATIVE DENSITY OF A GAS OR A VAPOUR
The density of a gas or a vapour relative to the density of air at the same pressure and at the same temperature (Air is equal to 1.0).

3.19 ZONES
Hazardous areas are classified in zones based upon the frequency of the appearance and the duration of an explosive gas atmosphere as follows.

3.19.1 Zone 0 - An area in which an explosive atmosphere is present continuously or for long periods or frequently.

3.19.2 Zone 1 - An area in which an explosive atmosphere is likely to occur in normal operation occasionally.

3.19.3 Zone 2 - An area in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

3.20 TEMPERATURE CLASS
A system of classification by which an electrical apparatus is allocated temperature classes according to its maximum surface temperature.

3.21 INCENDIARY ENERGY
Hot particle energy sufficient to ignite a specific ignitable mixture.
4.0 CLASSIFICATION OF FLAMMABLE PRODUCTS

4.1 GENERAL

Three basic conditions must be satisfied for the occurrence of fire or explosion as indicated below.

(i) A flammable gas or vapour must be present.
(ii) It must be mixed with air or oxygen in the proportions required to produce a flammable or ignitable mixture.
(iii) There must be an ignition source of this mixture. The potential source of ignition is electrical installation operating at energy level sufficient to release incendiary energy.

While analysing any potential hazard, the quantity of the substance that might be liberated, its physical characteristics and the natural tendency of vapours to disperse in the atmosphere should be considered in detail.

4.2 FLAMMABLE SUBSTANCES

Flammable substances, the potential release of which must be considered in area classification for electrical installations, include flammable gases, liquefied petroleum gases (LPG) and vapours of flammable liquids.

4.2.1 Flammable Gases

Flammable gases commonly encountered include methane and its mixture with small quantities of low-molecular weight hydro-carbons, which are generally lighter than air. Hydrogen because of its unique properties shall be given special consideration.

Flammable gases released from an opening of given size will dissipate rapidly because of their low relative density and will not usually affect as wide an area as the liquefied petroleum gases.

4.2.2 Liquefied Petroleum Gas

Liquefied Petroleum gases include propane, propylene, butane, butylene and their mixture having relative density from 1.5 to approximately 2.0 times more than that of air. Vapour pressure of these gases exceeds 2.81 kg/cm2 at 37.8 degree C.

These gases in their liquefied state are highly volatile and have low boiling temperature so that they readily pick up heat creating large volumes of vapour. They should be treated very conservatively in considering the extent of areas affected, since the heavy vapours travel along the ground for long distances if air currents do not assist diffusion.

4.2.3 Flammable Liquids

Flammable liquids vary in volatility and have a flash point below 93 degree C. These are divided into three classes as follows on the basis of volatility

CLASS A: Flammable liquids having flash point below 23 degree C.
CLASS B: Flammable liquids having flash point 23 degree C and above but below 65 degree C.
CLASS C: Flammable liquids having flash point 65 degree C & above but below 93 degree C.

The saturated vapours of these flammable liquids at atmospheric pressure and ambient temperature are generally heavier than that of air and tend to settle down at lower levels.

4.2.3.1 Class A liquids may produce large volumes of vapour when released in appreciable quantities to the open.

4.2.3.2 Class B liquids are heavier and less volatile than Class A but flash point is at or slightly below normal ambient air temperatures. At normal storage temperatures such liquids release vapour slowly and are hazardous only near the surface of the liquid. At elevated temperatures Class B liquids approach the characteristics of Class A liquids in respect of vapour release.
4.2.3.3 Class C liquids include a broad range from cleaner’s solvent to heavy fuel oil in commercial grades. The degree of hazard is low because the rate of vapour release is nil at normal ambient temperatures of handling and storage. When vapours from heated Class C products in process area released to the atmosphere, the chance of ignition by electrical equipment is not as great as in case of Class A or Class B liquids because vapours either condense rapidly or ignite spontaneously.

4.2.3.4 Normally Class A and Class B liquids will produce vapours considered to be in flammable range for electrical design purposes. Class C liquids should be considered as producing flammable vapours when handled, processed or stored under such conditions that the temperature of the liquid, when released to the atmosphere, would exceed its flash point.

4.2.4 LIQUEFIED NATURAL GAS (LNG)

Natural gas is liquefied at a temperature in the range of at (-) 162 °C to (-) 168 °C and atmospheric pressure to facilitate transportation in the form of LNG. After vaporisation the same can be used to meet the gas demand. LNG is a colourless, odourless, low density and slightly viscous liquid. The main characteristic of LNG is that its specific volume is nearly 600 times that of natural gas in the gaseous state. Owing to this characteristic, greater quantities can be stored / transferred in liquid state than in gaseous phase. Generally LNG at temperature below approximately (-) 112 °C, is heavier than ambient air at 15.6 °C. However as its temperature rises, it becomes lighter than the air. The predominant component of LNG is methane.

4.3 GAS GROUPS (APPARATUS GROUPS)

All gases normally encountered in industry are categorised into Group-I and Group-II gases. Group-I gases are those which are found in the coal mining industry and are not covered in this standard. Basis of classifying gases & vapours into various groups shall be as per IS-9570.

Group-II gases have been further subdivided into three main representative subgroups namely Group-IIA, Group-IIB, and Group-IIC in the increasing order of their explosiveness.

Group-IIA: Atmosphere containing acetone, ammonia, ethyl alcohol, gasoline, LPG/ Propane.
Group-IIB: Atmosphere containing ethylene, acetaldehyde.

It should be noted that apparatus subgrouping is normally applied specifically to the technique of flame proof enclosure and to the limiting energy levels of the intrinsic safety type of protection.

Apparatus certified for a particular subgroup may be used with gases allocated to a lower subgroup subject to consideration of temperature classification.

IEC 60079-20-1 should be referred for properties of flammable gases, vapours and liquids.

4.4. TEMPERATURE CLASSIFICATION

The definition of Temperature Class is used to classify a flammable gas or vapour by its ability to get ignited by a hot surface. The temperature class defines the maximum surface temperature an electrical apparatus is allowed to operate at. The maximum surface temperature of the apparatus must always be lower than the ignition temperature of the surrounding gases or vapours mixed with air at normal pressure.

Apparatus, that are certified suitable for use in a hazardous area, should be marked with their temperature class. Those are given a temperature classification consisting of two-digit code; the first
digit is the letter "T" and a second number between 1 and 6. The Temperature Classes or 'T' classes are given in table:

<table>
<thead>
<tr>
<th>Temperature Class</th>
<th>Max Surface Temperature of Apparatus in °C</th>
<th>Ignition Temperature of the Flammable Substance in °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>450</td>
<td>&gt;450</td>
</tr>
<tr>
<td>T2</td>
<td>300</td>
<td>&gt;300 ≤450</td>
</tr>
<tr>
<td>T3</td>
<td>200</td>
<td>&gt;200 ≤300</td>
</tr>
<tr>
<td>T4</td>
<td>135</td>
<td>&gt;135 ≤200</td>
</tr>
<tr>
<td>T5</td>
<td>100</td>
<td>&gt;100 ≤135</td>
</tr>
<tr>
<td>T6</td>
<td>85</td>
<td>&gt;85 ≤100</td>
</tr>
</tbody>
</table>

5.0 CLASSIFICATION OF HAZARDOUS AREA

5.1 GENERAL

Areas classified herein cover both temporarily and permanently installed facilities under normal operations in which abnormal conditions may exist for which practical protection is possible.

The standard does not cover a major catastrophe against which practical protection is impossible. All hazardous areas containing ignitable and explosive mixtures are classified.

The term "abnormal" is used in a limited sense. Catastrophic in this context is applied, for example to the rupture of process vessel or a pipeline. Area classification norms do not apply to catastrophic failures that are beyond the concept of abnormality in this code.

Normal operation is intended to be the situation that all plant equipment is operating within its design parameters and includes start up and shut down operation. Minor releases of flammable material may be part of normal operation but leakage which entail repair or shut down are not part of normal operation.

The heavier than air vapours and mist of hydrocarbon are not as easily dissipated in the atmosphere as the lighter than air vapour and mist. Also, lighter than air gas or vapour will rise in a comparatively still atmosphere whereas heavier than air gas or vapour will tend to sink and may thereby spread some distance horizontally at a low level.

5.2 AREA CLASSIFICATION

To determine the type of electrical installation appropriate to a particular situation, the hazardous areas have been classified into three zones namely zone - 0, zone - 1 and zone - 2 according to the probability of the presence of hazardous atmosphere.

5.2.1 Zone - 0

An area in which an explosive atmosphere is present continuously or for long periods or frequently. Examples are vapour space above closed process vessels, storage tanks or closed containers, areas containing open tanks of volatile, flammable liquids etc.

5.2.2 Zone-1

An area in which an explosive atmosphere is likely to occur in normal operation occasionally. Zone-1 locations may be distinguished when any of the following conditions exist:
- Flammable gas or vapour or mist concentration is likely to exist in the air under normal operating conditions.
- Flammable atmospheric concentration is likely to occur frequently because of maintenance, repairs or leakage.
- Failure of process, storage or other equipment is likely to cause an electrical system failure simultaneously with the release of flammable gas or liquid.
- Flammable liquid or vapour piping system containing valves, meters, screwed or flanged fittings is in an inadequately ventilated area.
- The area below the surrounding elevation or grade is such that flammable liquids or vapours or mist may accumulate therein.

The zone-1 classification typically includes:
1) Imperfectly fitted peripheral seals of floating roof tanks.
2) Inadequately ventilated pump rooms for flammable gas or for volatile, flammable liquids.
3) Interiors of Sample Retention Room/ Cabinet, sample bottle wash room as part of quality control laboratories, refrigerators and freezers in which volatile flammable materials are stored in lightly stoppered or easily breakable containers.
4) API Separators.
5) Oily waste water sewer/ basins/ Oil catchers.
6) LPG cylinder filling and cylinder evacuation area.
7) Areas in the immediate vicinity of vents and filling hatches.

5.2.3 Zone-2

An area in which an explosive atmosphere is not likely to occur in normal operation but, if it does occur, will persist for a short period only. Zone-2 locations may be distinguished when any one of the following conditions exists:
- The system handling flammable liquid or vapour is in an adequately ventilated area and is so designed and operated that the explosive or ignitable liquids, vapours or gases will normally be confined within closed containers or closed systems from which they can escape only during abnormal conditions such as accidental failure of a gasket or packing.
- The flammable vapours or mist can be conducted to the location as through trenches, pipes or ducts.
- Locations adjacent to Zone-1 areas.
- In case positive mechanical ventilation is used, the failure or abnormal operation of ventilating equipment can permit atmospheric vapour mixtures to build up to flammable concentrations.

5.3 AREAS NOT CLASSIFIED

In general, the following locations where flammable petroleum gases and volatile liquids are processed, stored, or handled are not classified. These areas are considered safe from the point of view of electrical installation:

a) Areas where the piping system is without valves, fittings, flanges or similar appurtenances.
b) Areas where flammable liquids or vapours or mist are transported only in suitable containers or vessels.
c) Areas where permanent ignition sources are present like areas where combustion occurs, for example flare tips, flare pits, other open flames / burners and hot surfaces.
d) Enclosed premises in which purging stream from safe atmosphere is continuously maintained, so that no opening therein may be a point of ingress of gas or vapours coming from external source of hazard.
e) Gas turbine installation meeting requirements of Annexure-I.
f) Diesel Generator room / shed having adequate ventilation.
g) Oil/gas fired boilers installation: Consideration should be given, however, to potential leak sources in pumps, valves etc. or in waste product and fuel lines feeding flame or heat producing equipment to avoid installing electrical devices which could then become primary ignition sources for such leaks.

NOTE:
(i) A protected fired vessel is not considered a source of ignition and the surrounding area is classified the same as for a hydrocarbon pressure vessel.
(ii) The area around the fired components and exhaust outlets of unprotected fired vessels need not be classified from the standpoint of electrical equipment.
(iii) The area around a flare tip or a flare pit need not be classified from the standpoint of installation of
electrical equipment. However the area classification for the associated equipment (for example, knock out drum, blow down pump etc.) located at grade level shall be followed, as applicable.

(iv) Lack of classification around unprotected fired vessels and flare tips does not imply the safe placement of fired vessels and flare tips in the proximity of other production equipment because those are themselves sources of ignition.

(v) Electrical equipment may be exposed to flammable gas during a purge cycle of a fired heater or furnace thereby requiring protecting measures as applicable.

6.0 EXTENT OF HAZARDOUS AREA

6.1 GENERAL CONSIDERATIONS

6.1.1 Properties of Flammable Substance

A complete knowledge of the physical properties of the flammable materials involved is essential for classifying a hazardous area. Properties of primary interest from an ignition standpoint are:
(a) Relative density
(b) Flammable limits
(c) Flash point
(d) Volatility
(e) Ignition temperature
(f) Ignition energy

Some of these characteristics have a direct influence on the degree and/or extent of hazardous areas while the others affect the design of electrical equipment.

6.1.1 (a) Where a gas or vapour is released into the atmosphere having a relative density less than one, the lighter vapour will rise in a comparatively still atmosphere. A vapour density greater than one, that is heavier than air indicates the gas or vapour will tend to sink, and may thereby spread over some distance horizontally at a lower level. The latter effects will increase with compounds of greater relative vapour density.

Note: In process industries, the boundary between compounds which may be considered lighter-than-air is set at a relative vapour density of 0.75. This limit is chosen so as to provide a factor of safety for those compounds whose densities are close to that of air, and where movement may not therefore be predicted without a detailed assessment.

(b) The lower the “lower flammable limit” the larger may be the extent of the hazardous area.

(c) A flammable atmosphere cannot exist if the flash point is significantly above the relevant maximum temperature of the flammable liquid. The lower the flash point, the larger may be the extent of the hazardous area.

(d) Boiling point can be used for comparing the volatility of flammable liquids. The more volatile a liquid and the lower will be its boiling point, the more closely it approximates a flammable gas.

(e) Ignition temperature and ignition energy of a flammable gas or vapour affect the design of electrical apparatus for hazardous areas so that these do not present an ignition risk.

6.1.2 Factors Affecting Extent of Hazard

In addition to the properties of flammable materials involved, following factors need to be considered for determining the degree and extent of hazardous area while applying the guidelines given in this document

(a) The extent of a hazardous area may increase with increasing temperature of process liquid provided the temperature is above the flash point. It should be noted that the liquid or vapour temperature after the release may be increased or decreased by the ambient temperature or other factors e.g. a hot surface.

Note: Some liquids such as certain halogenated hydrocarbons do not possess a flash point although they are capable of producing a flammable atmosphere; in these cases, the equilibrium
liquid temperature corresponding to saturated concentration at lower flammable limit should be compared with the relevant maximum liquid temperature.

(b) For flammable liquids, the concentration of the released vapour is related to the vapour pressure at the relevant maximum liquid temperature. The lower the initial boiling point the greater the vapour pressure for given liquid temperature and hence the greater concentration of vapour at the release source resulting in greater extent of hazardous area.

(c) The extent of hazardous area may increase with increasing rate of release of flammable material.

(d) Due to an improved dilution for release of flammable gases, vapours and/or mists in the air, the extent of hazardous area may decrease if, with constant release velocity increases above that which causes turbulent flow.

(e) Air currents may substantially alter the outline of the limits of potential hazard. A very mild breeze may serve to extend the area in those directions to which vapours might normally be carried. However, a stronger breeze may so accelerate the dispersion of vapours that the extent of potentially hazardous area would be greatly reduced.

(f) With an increased rate of ventilation, the extent of hazardous area may be reduced. The extent may also be reduced by an improved arrangement of the ventilation system.

(g) Obstacles e.g. dykes, walls may impede the ventilation and thus may enlarge the extent. On the other hand, they may limit the movement of a cloud of an explosive gas atmosphere and thus may reduce the extent.

(h) Elevated or depressed sources of release will alter the areas of potential hazards.

(i) For heavier-than-air vapour released at or near ground level, the areas where potentially hazardous concentrations are most likely to be found are below ground, those at ground are next most likely, and as the height above ground increases, the potential hazard decreases.

Note: For lighter-than-air gases the opposite is true, there being little or no potential hazard at the below ground and greater potential hazard above ground.

(j) During prolonged rainfall, flammable liquids may flow from hazardous areas to safe areas due to flooding, and alter extent of hazardous area.

6.2 HEAVIER THAN AIR GASES AND VAPOURS

6.2.1 Open Air Situations

Figures 1 and 2 illustrate the situation when a source of hazard which may give rise to a hazardous atmosphere only under abnormal conditions is located in the open air. The hazardous area should in this case be classified as Zone 2. For heavier-than-air gases and vapours the classified hazardous area shall extend vertically 8 m above the source of hazard and horizontally 16 m in all directions from the source of hazard. Beyond 8 m from the source of the hazard in the horizontal plane the vertical extent of the Zone 2 area may be reduced to 8 m above ground level.

6.2.1.1 If there is a possibility of large release of volatile products, the Zone 2 area may be further extended horizontally beyond 16 m up to 32 m with a height of 0.63 m.

6.2.1.2 In case of petroleum pipelines where well maintained valves, fittings, and metering instruments of a pipeline system transporting petroleum (crude oil, products, and gases) are installed in well ventilated situations or in a pit, the extent of the Zone 2 area above ground may be considered as 3 m in all directions from the possible source of hazard, although the pit itself should be classified as Zone 1 area.

Note: Any trench or pit below ground level and located within the area defined above should be classified as Zone 1 area.

NOTES:
1. If the source of hazard gives rise to a hazardous atmosphere under normal operating conditions, the area described in 6.2.1 as Zone 2 should be classified as Zone 1.
2. In the event of an enclosed premises not containing a source of hazard but situated within either a Zone 1 or Zone 2 area the inside of the premises should be classified as Zone 1 unless separated from the outside hazardous area by a vapour tight wall.
6.2.2 Enclosed Premises and surrounding areas

6.2.2.1 Figures 3 and 4 illustrate the situation when a source of hazard which may give rise to a hazardous atmosphere under abnormal conditions is located within enclosed premises. The whole of the inside of the building should be classified as Zone 1, as rapid dispersal of hazardous atmosphere may not be expected due to lack of ventilation.

6.2.2.2 The Zone 2 area shall extend 16 m horizontally from the source of hazard and 8 m vertically from the ground level. If the area covered above does not contain the area 3 m past the perimeter of the building, the Zone 2 area shall be extended in such a way that this area is covered. In case of unpierced vapour-tight walls, the area 3 m past perimeter need not be considered within Zone 2 area.

6.2.2.3 If there is a possibility of large release of volatile products, Zone 2 area may be further extended horizontally beyond 16 m up to 32 m with height of 0.63 m.

NOTE - Any trench or pit below ground level and located within the area defined should be classified as Zone 1 area.

6.2.2.4 If the source of hazard within the enclosed premises gives rise to hazardous atmosphere under normal conditions, the area within the building should be classified as Zone 1 and the area described in 6.2.2.2 & 6.2.2.3 as Zone 2 should be classified as Zone 1.

6.2.2.5 When the building has a ridge type roof with ventilators, special consideration is necessary in connection with the vertical extent of the hazardous area, as shown in Fig 4.

6.2.3 Storage Tanks

Figure 5 illustrates the classification of the area surrounding a floating roof tank under normal operating conditions.

Figures 6 and 7 illustrate the classification of the area surrounding a fixed roof tank (with and without nitrogen blanketing) under normal operating conditions.

6.2.3.1 In case of floating roof tanks, the space above the roof and within the shell of the tank should be classified as Zone 1. The area surrounding the tank should be classified as Zone 2. It shall extend vertically 3 m above the tank or shall be horizontally 3 m from it. If there is a dyke on any side of the tank, Zone 2 area should extend up to the dyke, the vertical extension from the ground level being the same as the height of the dyke.

In addition, the area extending 1.6 m beyond the shell top in all outward directions shall be considered as Zone 1 area.

6.2.3.2 In the case of fixed roof tanks with nitrogen blanketing (which breathe into closed system and not to atmosphere during filling/emptying), the area surrounding the tank shall be classified as Zone - 2, as shown in Fig - 6. However, for fixed roof tanks without nitrogen blanketing, the area surrounding the tank should be classified as Zone 1, as shown in Fig - 7.

NOTE - Any trench or pit below ground level and located within the area defined should be classified as Zone 1 area.

6.2.4 Pressure Storage Vessels

Figures 8 and 9 illustrate the classification of the area surrounding pressure storage (spheres and bullets) under normal operating conditions.

6.2.5 Mounded Storage

The underground mounded storage shall not be considered as a source of hazard for the purpose of area classification. However, the area extending to 3m in all directions surrounding the associated appurtenances (valves, fittings, meters etc) located above ground shall be classified as Zone 2 area.
6.3 LIGHTER THAN AIR, GASES AND VAPOURS

6.3.1 Open Air Situations

a) Fig. 10 illustrates the situation when a source of hazard which may give rise to a hazardous atmosphere only under abnormal conditions is located in the open air. The hazardous area should in this case be classified as Zone 2.

If the source of hazard gives rise to a hazardous atmosphere under normal operating conditions, the area described in Fig.10 as Zone 2 should be classified as Zone- 1.

b) For typical Hydrogen reactor, the vertical and horizontal extents of Zone-2 hazardous area are illustrated in Fig. 11.

c) In case of petroleum pipelines where well maintained valves, fittings and metering instruments of a pipeline system transporting gases are installed in well ventilated situations or in a pit, the extent of the Zone 2 area above ground may be considered as 3 m in all directions from the possible source of hazard.

6.3.2 Source of Hazard Located inside Enclosed Premises

Figs. 12 to 17 illustrate the situation when a source of hazard which may give rise to a hazardous atmosphere under abnormal conditions is located within enclosed premises.

If the source of hazard within the enclosed premises gives rise to hazardous atmosphere under normal conditions, the area within the buildings as Zone 2 in Figs. 12 to 16 should be classified as Zone 1.

6.4 MISCELLANEOUS INSTALLATIONS

6.4.1 For typical installations encountered in plants and jetties handling oil and gas, area classification for certain additional cases are given in the following figures:

- Fig. 18 : Storage for cryogenic liquids.
- Fig. 19 : Cooling towers for cooling water associated with equipment handling flammable material.
- Fig. 20 : Wagon / truck loading / unloading system for flammable liquids.
- Fig. 21 : Wagon / truck loading / unloading system for liquefied gas / compressed gas / cryogenic liquids.
- Fig. 22 : Typical vent installation.
- Fig. 23 : Typical drum dispensing installations.
- Fig. 24 : Pig launching / receiving installation in a non-enclosed adequately ventilated area.
- Fig. 25 : Separators, Dissolved Air Floatation (DAF) units and Biological Oxidation (BIOX) units.
- Fig. 26 : Enclosed premises with internal source of release.
- Fig. 27 : Jetties and Marine facilities.

6.4.2 The area within 1.5m (extending in all directions) of safety vents, product sampling locations, process water drains, oily sewer vents, inspection hatches, discharge orifice of fixed liquid gauges, rotary or dip gauges, filler openings shall be classified as Zone 1. Further an area from 1.5 m to 3m (extending in all directions) from vents shall be classified as Zone 2.

**NOTE** - However the vents, drains and inspection hatches etc. blanked during normal operation and used only when the plant is depressurized or under shut down, should not be regarded as source of hazard.

6.4.3 Any trench or pit below ground level and located within the Zone 2 area should be classified as Zone 1 area, where heavier than air gases or vapours are being handled. However wide shallow depressions used for pumping complexes or pipe reservations may be classified as Zone 2 area.
Note: Distances given must be used with judgement considering all factors discussed in this standard.

* Area suggested where large release of volatile product may occur

FIG 1: Freely Ventilated Process Area – Source of Hazard located near Ground Level (Heavier-Than-Air Gases OR Vapours)

Note: Distances given must be used with judgement considering all factors discussed in this standard.

* Area suggested where large release of volatile product may occur

FIG 2: Freely Ventilated Process Area – Source of Hazard located above Ground Level (Heavier-Than-Air Gases OR Vapours)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

* Area suggested where large release of volatile products may occur

FIG 3: Process Area with Restricted Ventilation

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 4: Well Ventilated Indoor Area (Heavier-Than-Air Gases OR Vapours)
FIG 5: Tank with Floating Roof with OR without Protective Cone Roof

FIG 6: Fixed Roof Tank (with N₂ Blanketing)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 7: Fixed Roof Tank (without N₂ Blanketing)

Note: Distances given must be used with judgement considering all factors discussed in this standard.

* Area suggested where large release of volatile product may occur

FIG 8: Pressure Storage Tank – Sphere (Heavier-Than-Air Gases OR Vapours)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

* Area suggested where large release of volatile product may occur

**FIG 9 : Pressure Storage Tank - Bullet**
(Heavier-Than-Air Gases OR Vapours)**
If the source of hazard is situated at a height less than or equal to 4.5 m above the ground, the height of the hazardous area extends below the source of hazard up to ground level. The entire area is Zone-2.

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 10: Freely Ventilated Process Area
(Lighter-Than-Air Gases OR Vapours)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 11: Typical Equipment in Freely Ventilated Process Area (Lighter-Than-Air Gases OR Vapours)
In this case the entire area within the enclosed premises is a Zone 1 area and the extremities of the openings are considered as source of hazard.

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 12: Source of Hazard located Inside Enclosed Premises with Restricted Ventilation – Opening on Top and Bottom (Lighter-Than-Air Gases OR Vapours)
In this case the entire area within the enclosed premises is a Zone 1 area and the extremities of the openings are considered as source of Hazard.

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 13: Source of Hazard located Inside Enclosed Premises with Restricted Ventilation – Opening on sides (Lighter-Than-Air Gases OR Vapours)
In this case the area within the enclosed premises above the opening is Zone 1 whereas the rest of the enclosed premises form a Zone 2 area.

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 14: Source of Hazard located Outside the Enclosure with One Side Open (Lighter-Than-Air Gases OR Vapours)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 15: Inadequately Ventilated Compressor Shelter (Lighter-Than-Air Gases OR Vapours)

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 16: Adequately Ventilated Compressor Shelter (Lighter-Than-Air Gases OR Vapours)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 17: Process Area with Restricted Ventilation (Lighter-Than-Air Gases OR Vapours)
Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 18: Storage Tanks for Cryogenic Liquids
Note: Distances given must be used with judgement considering all factors discussed in this standard.

**FIG 19:** Cooling Towers for Cooling Water associated with Equipment Handling Flammable Material
Vapour of Return Line
1.5 m Radius

1.5 m Radius

Sump/ Pit/ Trench

Liquid Transfer Line

0.63 m
Ground level

(Material: Flammable Liquid)

Wagon/ Tank Truck Loading and Unloading via Closed System. Bottom Product Transfer only.

4.5 m Radius

Liquid Transfer Pipe

1.5 m Radius

Sump/ Pit/ Trench

(Material: Flammable Liquid)

Wagon/ Tank Truck Loading and Unloading via Open System. Top or Bottom Product Transfer.

Zone-1

Zone-2

Non-Hazardous

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 20: Wagon/ Truck Loading/ Unloading System for Flammable Liquid (cont..)
Wagon/ Tank Truck Loading and Unloading via Closed System. Product transfer through Dome only.

Zone-2  Non-Hazardous

Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 20: Wagon/ Truck Loading/ Unloading System for Flammable Liquid
Note: Distances given must be used with judgement considering all factors discussed in this standard.

FIG 21 Wagon/ Truck Loading/ Unloading System for Liquefied Gas/ Compressed Gas/ Cryogenic Gas
FIG 22: Typical Vent Installation

FIG 23: Typical Drum Dispensing Installation
FIG 24: Pig launching/ receiving installation in a non enclosed adequately ventilated area
FIG 25: Separator, DAF Units and BIOX Units
Flammable Substance released during Normal Operation with Inadequate Ventilation

Flammable Substance released during Abnormal Situation or Infrequent Operations with Inadequate Ventilation

Flammable Substance released during Abnormal Situation or Infrequent Operations with Adequate Ventilation

FIG 26: Enclosed Premises with Internal Source of Release
SECTION 1 - 1

PLAN

Zone-1

Non-Hazardous

▲ Shall be reduced to 15m in case of Vessel with loading or Discharge rate ≤ 10 m³ / Min

FIG 27: Jetties or Marine Facilities
7.0 REFERENCES

1. IS 5571 : Guide for Selection of Electrical Equipment for Hazardous Area
2. IS 5572 : Classification of Hazardous Areas (other than mines) having Flammable Gases & Vapours for Electrical Installations
3. IS 9570 : Classification of Flammable Gases or Vapours with Air according to their Maximum Experimental Safe Gaps and Minimum Igniting Current
4. IS/ IEC 60079-0 : General Requirements for Electrical Apparatus for Explosive Gas Atmospheres
5. The Petroleum Rules
6. NFPA 497A : Recommended Practice for Classification of Class I Hazardous (Classified) Location for Electrical Installations in Chemical Process Areas
7. API RP 500 : Classification of locations for Electrical Installations in Petroleum Refineries
8. SP-30 (BIS) National Electric Code
11. IS/ IEC60079-20-1: Material characteristics for gas and vapour classification – Test methods and data
12. API RP 505: Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone O, Zone 1, and Zone 2
ANNEXURE – I

GAS TURBINE INSTALLATIONS

A-1 INTRODUCTION
A-1.1 This Annex applies to gas fired turbine installations.
A-1.2 If the turbine is equipped with an acoustic hood or other enclosure containing parts of the fuel gas system, this enclosure should be defined as the turbine hood.
A-1.3 If the turbine, with or without a turbine hood, is located in an enclosed area, this area should be defined as the turbine room.

A-2 AREA CLASSIFICATION OF THE TURBINE ROOM
A-2.1 In order to classify the turbine room as non-hazardous, the following requirements should both be fulfilled:
   a) The turbine room should be adequately ventilated that is at least 12 air changes per hour with proper ventilation patterns. The ventilation system should be arranged so that an over-pressure of at least 50 Pa (0.5 mbar) is maintained in the turbine room with respect to the inside of the turbine hood and any surrounding classified areas with openings to the turbine room. A pressure switch should be installed in order to give an alarm at manned location if the differential pressure drops below 50 Pa (0.5 mbar).
   b) The fuel gas pipe to each turbine hood should have no more than one pair of flanges inside the turbine room. All other equipment such as valves, connections, filters, drip pot etc., have to be located either:
      - outside the turbine room.
      - inside an enclosure separately ventilated.
      - inside the turbine hood provided a special ventilation of turbine hood.
      - inside turbine hood, provided a special fuel gas supply arrangement as described in A-4.

A-2.2 The turbine room may be classified as Zone 1 or Zone 2 if the arrangement is not in compliance with the requirements stated in A-2.1 or due to other sources of hazard outside the turbine hood. The turbine or any associated equipment including exhaust piping, should not have a surface temperature above 200°C or above 80 percent of the ignition temperature for the actual gas/air mixture in the classified area without special precautions.

A-3 VENTILATION OF THE TURBINE ROOM
A-3.1 The turbine hood for a gas fired turbine should be adequately ventilated with respect to the removal of heat from the machinery and dilution of flammable gas as shown in Fig. G1. The air should be taken from non-hazardous area.
A-3.2 If the area outside the turbine hood is classified as non-hazardous, the ventilation system should be arranged so that an under pressure of at least 50 Pa (0.5 mbar) is maintained inside the turbine hood with respect to the outside. This differential pressure may be the combined effect of the under pressure inside the turbine hood and the over pressure in the turbine room.
A-3.3 If the area outside the turbine hood is Zone 2 and the turbine hood contains any source of ignition such as a surface with temperature above 200°C, or above 80 percent of the ignition temperature for the actual gas/air mixture the ventilation system of the turbine hood should be arranged so that an over pressure of at least 50 Pa (0.5 mbar) is maintained inside the hood with respect to the outside.
A-3.4 In both situations described above a pressure switch should be installed in order to give an alarm and shutdown after time delay if the differential pressure drops below 50 Pa (0.5 mbar).
A-3.5 The number of leakage sources under the turbine hood should be kept to a minimum. However, a manufacturer may require some leak prone equipment to be located inside the turbine hood. The number of air changes required depends upon the probable sources of leakage, the surface temperature of the
A-3.6 As an alternative to ventilation of the turbine hood during shutdown of the turbine, fire extinguishing gas may be injected.

A-3.7 Provided electrical equipment inside the hood which does not meet zone requirement, the turbine hood should be pre-purged with at least 5 air changes before starting the turbine or energizing any electrical equipment not suitable for Zone 1 area.

A-3.8 The fan used for pre-purging should meet Zone 1 and should be equipped with a starter suitable for Zone 1 or a starter in an area remaining non-hazardous during shutdown.

A-4 AREA CLASSIFICATION OF THE TURBINE HOOD

A-4.1 The combination of ventilation, fuel gas system arrangement, temperature on exposed surfaces, electrical equipment inside the turbine hood, etc. should be considered to evaluate the safety of the turbine hood. The safety principles will be elucidated by some of the most common turbine/turbine hood designs.

A-4.2 No Exposed Surface of the Turbine Inside the Hood will have a Temperature Above 200°C During Operation

Provided the ventilation system provides at least 12 air changes per hour, the hood should be considered as adequately ventilated. The area inside the hood will be regarded as zone 2 area and accordingly all equipment inside the hood have to meet Zone 2 requirement. The equipment which has to be alive after a shut down or stop of ventilation of the hood, should meet Zone 1 requirement. This for instance applies to trace heater, post lubrication pumps etc. The post lubrication pumps should be supplied from emergency power sources to operate after a shutdown in order to prevent overheating of the bearings. Overheating may ignite flammable vapour or gas inside the hood.

A-4.3 The Turbine has Exposed Surfaces with Temperature above 200°C

If the actual flammable gas ignition temperature can be tested and a statement can be made that the surface temperature of the turbine will not exceed 80 percent of the ignition temperature, the same situation as described in A-4.2 above exists.
A-4.4 The Turbine has exposed Surfaces with Temperature above 80 Percent of the Ignition Temperature of the Actual Flammable Gas or the Electrical Equipment inside the Hood which will be Alive as the Turbine is Running does not meet Zone 2 Requirement

The hood then should be ventilated with sufficient number of air changes per hour to make a highly efficient dilution of any hazardous gas leakage inside the hood. The required ventilation rate depends on the leakage sources inside the hood and should be sufficient to keep the internal atmosphere below an average of 20 percent of the lower explosion limit. Ninety air changes per hour is regarded as a minimum. In addition to the normal ventilation system a 100 percent spare stand-by fan supplied from a continuous power source should be provided. If the ordinary ventilation fails the spare fan should be automatically activated and an alarm be given in the control room. As an alternative to ventilation of the turbine hood during shutdown of the turbine, fire extinguishing gas may be injected.

A-4.5 During a shut-down, the turbine hood may be classified as non-hazardous due to special arrangement of the fuel gas supply system. A system called “Block and Bleed” is described in Fig. G2. A shut down signal will close valve No. 1 and open valve No. 2. The three way valve will open from the gas distribution manifold to the flare. The fuel gas lines within the turbine room and the turbine hood will then be depressurized. The probability of gas escape inside the hood may then be regarded as minor. In case of a leak only small quantities of gas will escape. This arrangement does not reduce the requirements to ventilation while the turbine is running.

![Flowchart of Turbine Room](image)

**FIG G2: Block and Bleed System**

A-5 DETECTION OF ESCAPED GAS

A-5.1 Gas detectors should be installed inside the turbine hood. Normally, the turbine should shut down if gas is detected inside the hood.

A-5.2 The location of the detectors should be chosen with special care being aware of possible gas pockets, air flow patterns, etc.
A-5.3 Concerning ventilation arrangement, several alternatives exist in case of a shut down due to gas detection inside the hood
   a) The ventilation of the turbine hood continues until hot surfaces have been cooled to a temperature below 80 percent of the ignition temperature of the gas-air mixture which is present. The ventilation system that will be in operation after a shut down should be supplied from an emergency power source with sufficient capacity.
   b) The ventilation stops and fire extinguishing gas is released upon detection of gas inside the hood.
   c) Other alternatives may be considered depending on the actual installation.

A-6 ADDITIONAL RECOMMENDATIONS

A-6.1 The shut down of ventilation system should correspond to the fire and gas detection system and the fire extinction system installed in the turbine hood and turbine room. Accordingly, other arrangements than those described in this standard may give an equivalent level of safety.

A-6.2 Ventilation and combustion air should be taken from non-hazardous areas.