HAZARDOUS AREA CLASSIFICATION FOR CENTRAL PROCESSING FACILITY
(Saipem India Projects Limited - Chennai)

Final year project report

Submitted by

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BONAFIDE CERTIFICATE

Certified this titled "Hazardous Area Classification for Central Processing Facility" is the bonafide work of **Prashanth R (R080213026)** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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Abstract

This project is intended to present a practical approach to determining hazardous area classification for a Central processing facility. Crude processing involving flammable or combustible materials may produce explosive atmospheres. This facility involves in removing slug from the crude oil and in three phase separation of gases, oil and water by various equipment's. The processed crude oil is stored in storage tanks and gases are exported to the consumers.

Any processing Plant has a major role to play in preventing the ignition of any flammable release which may occur by the electrical and mechanical equipment installed. This could be done by classifying the critical equipment's into special zones in the layout of the plant. This aspect of layout is known as 'area classification'. The extension of this practice to cover the exclusion of all sources of ignitions is known as 'hazardous area classification'.

The detailed Hazardous Area Classification study of a Central processing facility have proven that the equipments can be classified into Zones that can prevent the ignition of any flammable release which may occur by the electrical and mechanical equipment installed in the facility. Thus proper protection for electrical and mechanical equipment will be given according to zones where it is installed.

Key Words: Area Classification, crude processing, explosive atmosphere.

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Abbreviation

HAC	Hazardous Area Classification
CPF	Central Processing Facility
HC	Hydrocarbons
FSU	Floating Storage Unit
LEV	Local Exhaust Ventilation
CFU	Compact Flotation Unit

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Hazardous area classification assessment is a probability analysis and risk assessment evaluation of a manufacturing or process area processing a potentially flammable atmosphere that focuses exclusively on the minimization or elimination of electrical energy as a potential source of ignition. Hazardous area classification should be carried out as an integral part of the risk assessment to identify places (or areas) where controls over ignition sources are needed (hazardous places) and also those places where they are not (non-hazardous places).

Hazardous places are further classified in Zones which distinguish between places that have a high chance of an explosive atmosphere occurring and those places where an explosive atmosphere may only occur occasionally or in abnormal circumstances. The definitions of the Zones also recognize that the chance of a fire or explosion depends on the likelihood of an explosive atmosphere occurring at the same time as an ignition source becomes active.

1.2 OBJECTIVE

The objective of the project is

- To determine the zone classification for the equipments of a Central Processing Facility.
- To determine the Hazard radii for individual sources of release from the process units.
- To reduce the probable coincidence of a flammable atmosphere and an electrical source of ignition by doing HAC.

CHAPTER 2: ABOUT THE PROCESS

2.1 CENTRAL PROCESSING FACILITY

Central processing facility belongs to the upstream activity to describe the production unit performing the first transformation of the crude oil after the production wells. The CPF is going to be installed as closed as possible to the production wells or offshore platform. The crude oil just collected from the wellheads can be directed by the shortest way to the CPF. If the main production of the field is crude oil, the purpose of the CPF is to separate the oil from the associated gas, the water, the sand and solvents or additives. The oil will be stored in tanks farm if onshore, or floating storage unit (FSU) if offshore, before being carried out by pipeline or shipped by tanker. The water may be treated and disposed or re-injected to enhance the production.

2.2 CRITICAL EQUIPMENTS OF CENTRAL PROCESSING FACILITY

The working flow diagram is give in figure 2.1 and the equipments brief descriptions are given respectively according to the process flow.

2.2.1 Pig Receiver

Receiver is the end of the pipe line from well head or off-shore platform from which the crude oil mixed with gases and mud is received in a slug form which is connected to the slug catcher for separation process

2.2.2 Slug catcher

It consists of a several long pipe in finger form which regulates the flow and separates gases and mud. Slug catcher is a static equipment used in the upstream oil production facilities to minimize the slug from oil and gas pipeline. Fluids extracted from oil and gas reservoirs contain crude oil, natural gas, water, salts etc. The multiphase flow in a pipeline often leads to formation of slug flow. This multiphase flow is received in a large vessel in the crude oil processing and storage facilities where the oil, water and gases are crudely separated to remove the slug.

2.2.3 Low Pressure Separator

The LP separator depressurizes the crude thus separating the free water and oil. The LP Separator is also used for protection of downstream equipment like compressors and flow meters. The Separator is capable of separating sand and other solid parts. Therefore the unit is also commonly used as a gas wellhead separator.

2.2.4 Gas scrubber

Gas Scrubber removes traces of liquid droplets from gas streams to protect downstream equipment from damage and failure. It is typically used upstream of gas treating equipment that contains dry desiccants or mechanical equipment such as compressors. It is also used downstream of equipment where liquids have condensed from the gas. The Gas Scrubber is designed to handle light liquid loads and does not take the place of a primary separator.

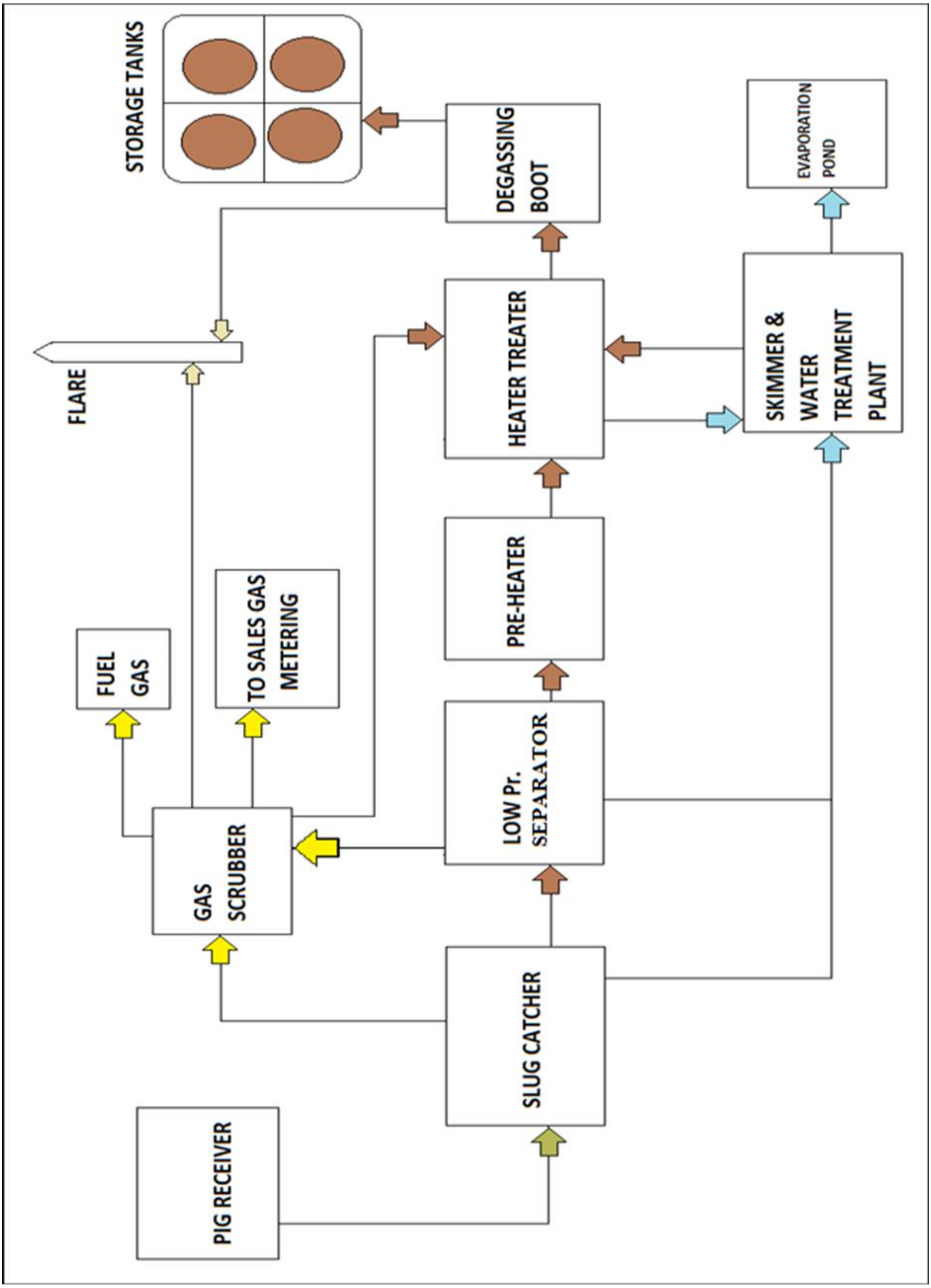


Figure 2.1: Block Diagram for Central Processing Facility

2.2.5 Heater Treater

Heater Treater breaks the oil emulsion to separate water and dissolved gases. It is used in the Oil and gas production process and is used to remove water and gas from the produced oil - and to improve its quality for sale into a crude oil pipeline or for other transport. A heater- treater tropical combines the following components inside the heater treater: a heater, free-water knockout, and oil and gas separator.

2.2.6 Degasser boot

The degasser is used for removing the least remaining gases and other non-usable gases form the crude and send to the flare. The liquids are decreased to just above the atmospheric pressure causing last traces of gases to release from liquid.

2.2.7 Storage tanks

The liquid crude is then sent to storage tank at atmospheric pressure for storing and transportation to refineries.

CHAPTER 3: MATERIALS & METHODOLOGY

3.1 HAZARDOUS AREA CLASSIFICATION

Hazardous Area Classification is for purpose of selection, design and installation of electrical equipment. Hazardous Area Classification is aimed at identifying areas, within a plant, where the electrical devices are to be suitable for the use, as determined by the classification itself, in order to avoid explosion/fire.

3.2 DATA REQUIRED FOR ASSESSMENT

- A process now diagram showing flows, temperatures and pressures.
- Flash points or, where more complex conditions requiring a point-source release approach apply, the boiling ranges or other relevant physical characteristics of the fluids handled are required.
- Piping and instrumentation diagram.
- A layout drawing with typical plans and elevations showing the position of all equipment, including operational vents and drains to atmosphere. In addition this should show principal sources of ignition such as heaters, roadways with unrestricted access, flares, workshops, hot work areas etc.
- Knowledge of the equipment features and the mode of operation.
- Consideration of ventilation, whether open area, restricted or enclosed. For sheltered or enclosed situations the positions of openings such as doors, windows and inlets/outlets will be needed. The location of below-grade areas, such as pits and pipe-trenches, should also be specified.

3.3 HAZARDOUS AREA CLASSIFICATION METHODOLOGY

In this project as per the client requirement the hazardous area classification is done using IP-15 standard which uses 3 approaches for determining the zones. The hazardous area classification methodology is given as a flow diagram in Figure 3.1 which is given by IP-15 standard.

3.3.1 Direct Example Method

Some arrangement of generic industrial equipment handling and common flammable material may be classified directly from typical examples. Such arrangement include drilling workover, wellhead site and tank storage.

3.3.2 Point Source Approach

Typical hazard radii arc provided, using the results of dispersion modelling. The hazardous area classification of point sources is determined using calculated hazard radii together with either the physical geometry or the shape factors to form a three-dimensional envelope of the hazardous area.

3.3.3 Risk Based Approach

Where a release rate (hole size and pressure) is unknown, a risk-based approach may be used. The risk-based approach methodology provides a means of adjusting release frequency and hence hazard radii, to fit specific process scenarios.

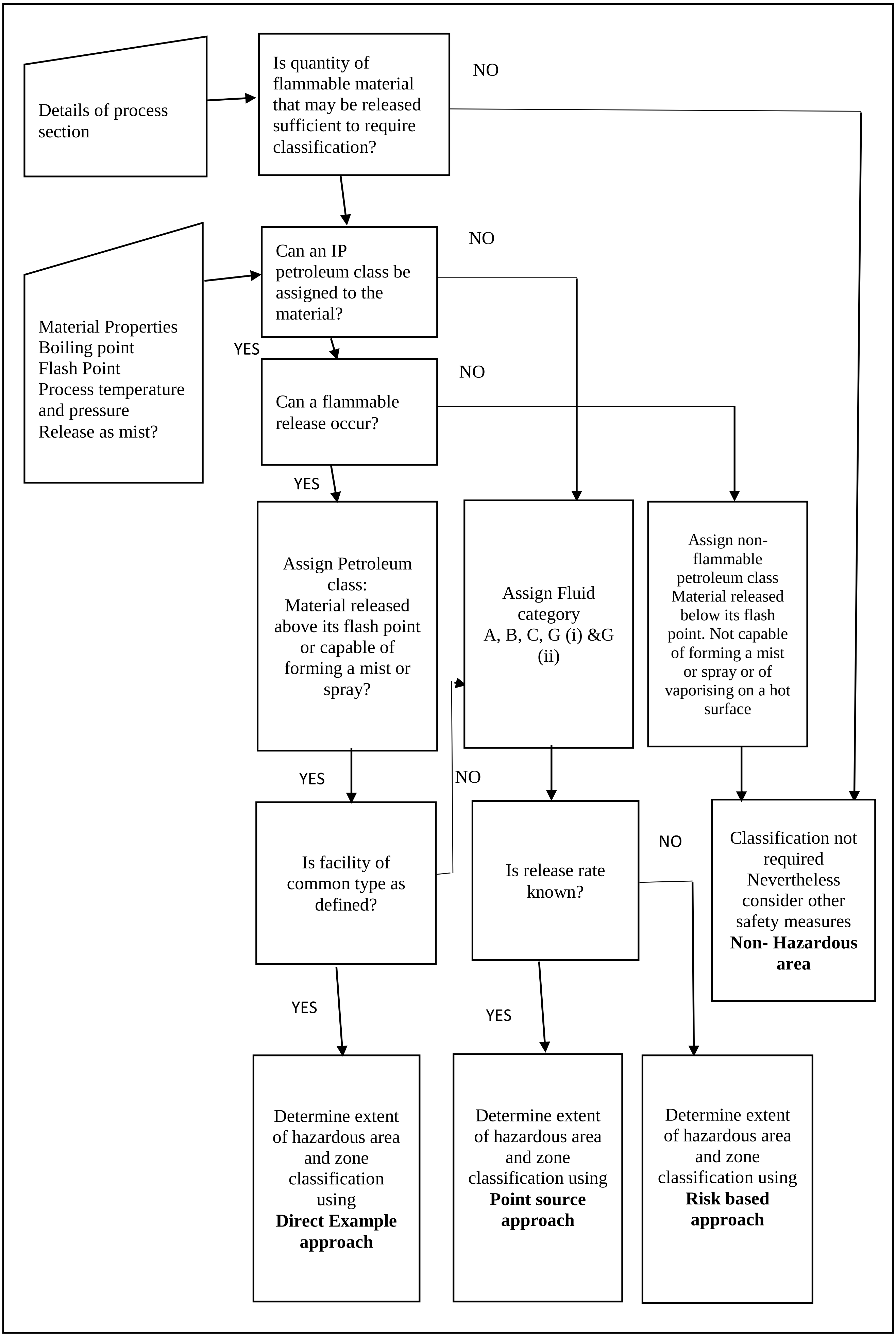


Figure 3.1: Hazardous Area Classification Methodology (IP-15)

3.4 CLASSIFICATION OF FLAMMABLE FLUIDS

Where flammable fluids are handled under more extreme conditions of temperature, pressure, composition and volatility, the simple classification for petroleum fluids is inadequate and the concept of fluid category given in table 3.1 has been introduced. This enables the determination of hazardous areas by use of the point source or risk-based approaches.

Table 3.1: Fluid categories (IP-15)

FLUID CATEGORY	DESCRIPTION
A	A flammable liquid that, on release, would vaporize rapidly and substantially. This category includes: (a) Any liquefied petroleum gas or lighter flammable liquid. (b) Any flammable liquid at a temperature sufficient to produce, on release. more than about 40% vol. vaporization with no heat input other than from the surroundings
B	A flammable liquid, not in category A, but at a temperature sufficient for boiling to occur on release.
C	A flammable liquid, not in categories A or B, but which can, on release, be at a temperature above its flash point, or form a flammable mist or spray.
G(i)	A typical methane-rich natural gas.
G(ii)	Refinery hydrogen.

Table 3.2: Relationship between IP petroleum Class and fluid category (IP-15)

Class	Description	Handled above flash point	Handled above boiling point	Can be released as mist	Handled below boiling point and cannot be released as mist
0	Liquefied Petroleum Gas	Yes	A	A	A
I	Flash point less than 21°C	Yes	B	C	C
II(1)	Flash point 21-55 °C	Yes	N/A	C	N/A
II(2)	Flash point 21-55 °C	Yes	B	C	C
III(1)	Flash point 55 -100 °C	Yes	N/A	C	N/A
III(2)	Flash point 55 -100 °C	Yes	B	C	C

3.5 SOURCE AND GRADE OF RELEASE

A source of release is defined as a point from which a flammable gas, vapour or liquid may be released into the atmosphere. Three grades of release are defined in terms of their likely frequency and duration

3.5.1 Grades of Release

Continuous grade release: A release that is continuous or that occurs frequently and for short periods. Continuous grade normally leads to Zone O.

Primary grade release: A release that is likely to occur periodically or occasionally in normal. Primary grade normally leads to Zone I.

Secondary grade release: A release that is unlikely to occur in normal operation and, in any event, will do so only infrequently and for short periods. Secondary grade normally leads to Zone 2.

3.5.2 Sources of Release

Point sources are pump seals, vents, drains, valves, piping flanges and filters/strainers. They are normally all secondary grade release sources because flanges are broken, filters opened and vents and drains operated, infrequently. Seal failure resulting in appreciable release of liquid is also unlikely.

Pig receivers and launchers are likely to be opened frequently and should normally be regarded as sources of primary grade release. The hazardous area should be classified as ZONE 1.

Drains and sample points should be graded according to the expected frequency of release. They should be regarded as at least primary grade release sources if used more than once a day, when classifying a drain point used only at shutdown, the fluid category should be based on the material at shutdown and the drain should be regarded as a secondary grade source of release.

Where a pit or depression exists in a hazardous area, without itself containing a source of release, it should be regarded as inadequately ventilated and therefore classified as Zone 1.

3.6 ZONE DEFINITION

A hazardous area is defined as a three-dimensional space in which a flammable atmosphere may be expected to be present at such frequencies as to require special precautions for the design and construction of equipment, and the control of other potential ignition sources. All other areas are non-hazardous in this context, though they may, in part or whole, from part of a wider restricted area within the facility in which all work is carried out under special controls. Areas are subdivided into zones based on the likelihood of occurrence and duration or a flammable atmosphere

Zone 0: That part of a hazardous area in which a flammable atmosphere is continuously present or present for long periods.

Zone 1: That part of a hazardous area in which a flammable atmosphere is likely to occur in normal operation.

Zone 2: That part of a hazardous area in which a flammable atmosphere is not likely to occur in normal operation and, if it occurs, will exist only for a short period.

Non-hazardous areas: Areas that do not fall into any of the above.

3.7 VENTILATION

Ventilation comprises the movement of air within and through a volume to achieve the introduction of fresh air into, and removal of contaminated air from the volume, and the mixing of air and contaminants within the volume. Gas or vapour released to the atmosphere will eventually be diluted by dispersion in free air until its concentration is at a safe limit (below LFL) The time taken for this to occur and the size and spatial location of the gas cloud depends upon the nature of the release, the vapour properties such as density relative to air, the movement of the air and the presence of turbulence to promote mixing. Procedure for assessing type and degree of ventilation is give in figure 3.2. Where the release is not into completely free air (i.e. not into an open area) then the air flow, or ventilation, is also a factor in determining the rate of gas or vapour dispersion. However, it is important to also consider, in a sheltered or obstructed open area or enclosed area, whether any recirculating motions may lead to a gradual accumulation of gas or vapour over time.

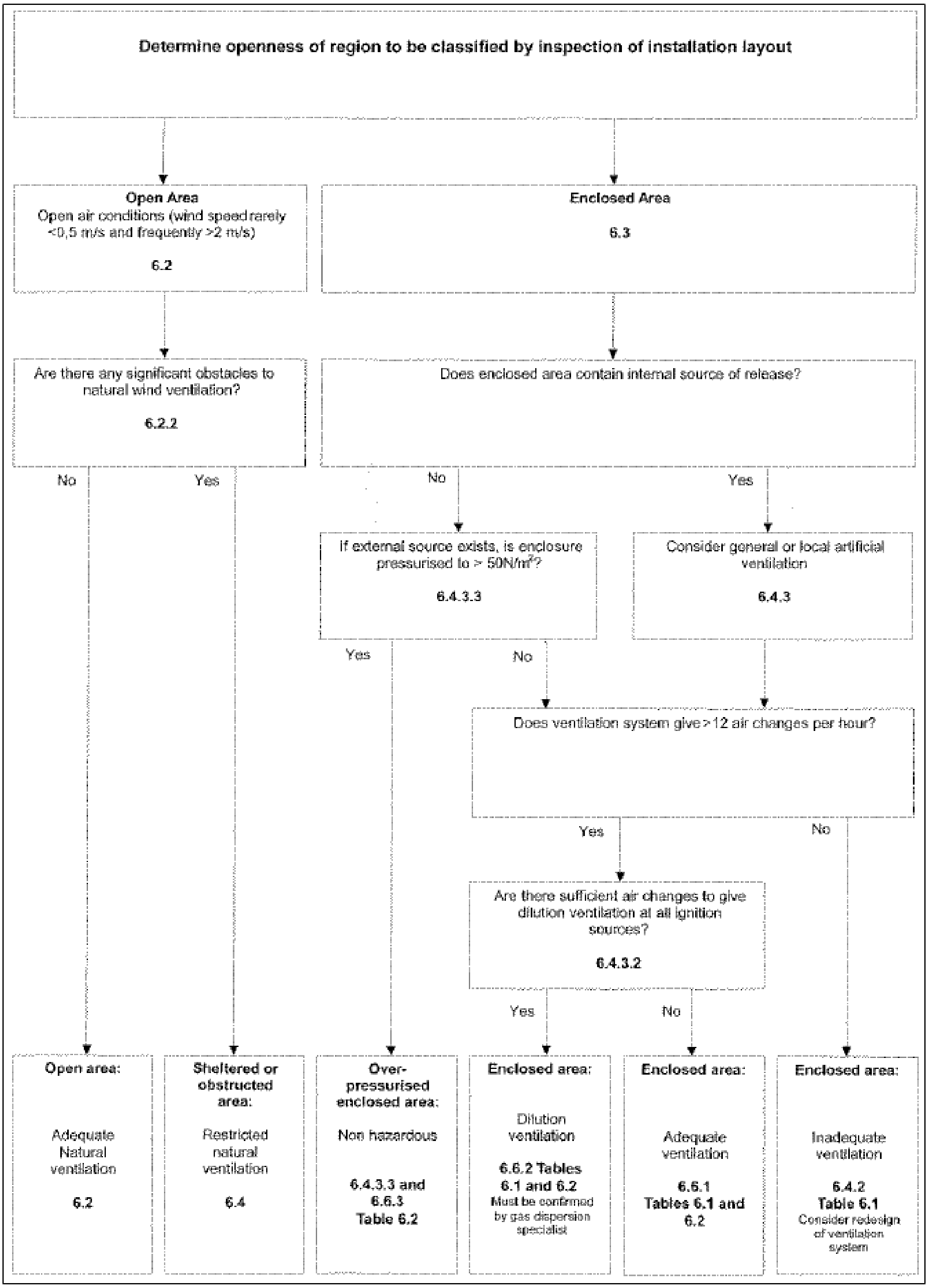


Figure 3.2: Procedure for assessing type and degree of ventilation (IP-15)

3.7.1 Open Areas

An open area is defined as an area that is outdoors without stagnant regions, where vapour is rapidly dispersed by wind and natural convection, Typically, air velocities will rarely be less than 0.5 m/s and will frequently be above 2 m/s. Obstructions such as dense trees, cliffs or other buildings preclude an area being considered open unless it can be shown that wind velocities meet the criteria within that particular area. Effect of ventilation on zone classification is given on Table 3.3.

Natural Ventilation is caused by wind or convection effects.

(a) Open air situations typical of those in the chemical and petroleum industries which comprise open structures, pipe racks, pump bays etc.

(b) Open buildings which having regard to the relative density of the gases and/or vapour involved have openings in the walls and for roof so dimensioned and located that the ventilation inside the building for the purpose of hazardous area classification can be regarded as equivalent to that in an open air situation.

3.7.2 Enclosed Areas

An enclosed area is any building, room or enclosed space within which, in the absence of artificial ventilation, the air movement will be limited and any flammable atmosphere will not be dispersed naturally. This section applies to buildings, rooms or enclosed spaces where there are potential sources of release of flammable vapour or gases, and natural ventilation does not provide a minimum of 12 air changes/hr. throughout the space. Normally, artificial ventilation (i.e. mechanical ventilation) should be provided in order to dilute and remove flammable gases or vapour released within the building. In most cases there ,will also be openings in the walls, through which flammable gases may migrate as a result of draughts, convection currents, or disturbance caused by equipment within the enclosed area.

Adequate Ventilation is to ensure that a building containing secondary grade release sources can be properly classified as Zone 2. In large buildings it may be possible to classify some parts as non-hazardous while other parts arc Zone 2.

Inadequate Ventilation area is not provided with artificial ventilation, air movement is likely to vary substantially and no general assumptions can be made about the mixing of a release. Continuous and primary grade sources of release should be avoided in such an area. Inadequately ventilated areas should be classified as Zone 1 since a secondary grade source may form a localised flammable atmosphere and persist for long periods.

3.7.3 Artificial Ventilation

Artificial ventilation may be applied to part of an area i.e., Local artificial ventilation, or to the whole area i.e., general artificial ventilation. Over-pressurisation for example may be applied either locally or generally, where ventilation is achieved by blowing fresh air into the building, diluted vapour will escape through all the openings. The flows are likely to be influenced by wind and convective forces. In any case, provided the atmosphere inside the building does not reach the LFL.

Local Exhaust Ventilation is a recommended means of controlling the release of flammable gases, where there are a small number of readily identifiable primary or secondary grade release sources. This is a common situation, including for example: a routine drum filling operation; a sampling point that is regularly used~ around equipment that needs regular opening for cleaning.

Over-Pressurisation is a system of ventilation for a room or other enclosed area, and also a protective method for a single item of electrical equipment. Applied to an enclosed area it is a form of artificial ventilation and should be designed so that a pressure differential of at least 50 *N/m2* is maintained between the enclosed area and any hazardous area.

Dilution Ventilation is in some restricted circumstances, a very high flow of air applied to a space, perhaps within some larger enclosed area, may be used to dilute and remove much larger releases than those controlled by LEV. A forced draught fan may be used in COI\junction with an extractor fan.

Table 3.3: Effect of ventilation on zone classification (IP-15)

Grade of Release source	**Ventilation**			
	Inadequate	**Adequate**	**Dilution** (Internal source of release)	**Over-pressure** (adjacent to an external hazardous area)
Continuous	Zone 0	Zone 0	Non-hazardous	Non-hazardous
Primary	Zone 0	Zone 1	Non-hazardous	Non-hazardous
Secondary	Zone 1	Zone 2	Non-hazardous	Non-hazardous

3.8 APPARATUS SUB GROUP AND TEMPERATURE CLASS

Not all flammable fluids are equally easy to ignite, and the different properties are usually measured as minimum ignition temperature, and minimum ignition energy. Electrical equipment standards recognise these differences by subdividing the equipment categories into subgroups, and temperature classes.

Table 3.4: Recommended apparatus sub-group and temperature class for some flammable fluids (IP-15)

Flammable fluid	Apparatus sub-group	Temperature (T) class of suitable equipment
Hydrogen	IIC	T1
Methane	IIA	T1
Ethane	IIA	T1
Propane	IIA	T1
LPG*	IIA†	T2
Ethylene	IIB	T2
Acetylene	IIC	T2
Benzene	IIA	T1
Toluene	IIA	T1
Xylene	IIA	T1
Gasoline*	IIA	T3
Naphtha*	IIA	T3
White spirit*	IIA	T3
Kerosine*	IIA	T3
Gas oil*	IIA	T2
Residual products*	IIA	T2
Crude oil*	IIA	T3

Table 3.5: Appropriate T class of equipment for common petroleum products (IP-15)

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

Since flammable gas or vapour can be ignited by contact with a hot surface, for all type of protection apparatus it is necessary to specify an appropriate Temperature (T) class, such that the maximum accessible surface temperature internally or externally will not exceed the ignition temperature of the gases and vapour to which it may become exposed

3.9 RISK BASED APPROACH

Where a release rate (Hole size and Pressure) is unknown, a risk-based approach may be used. The risk-based approach methodology provides a means of adjusting release frequency and hence hazard radii, to fit specific process scenarios.

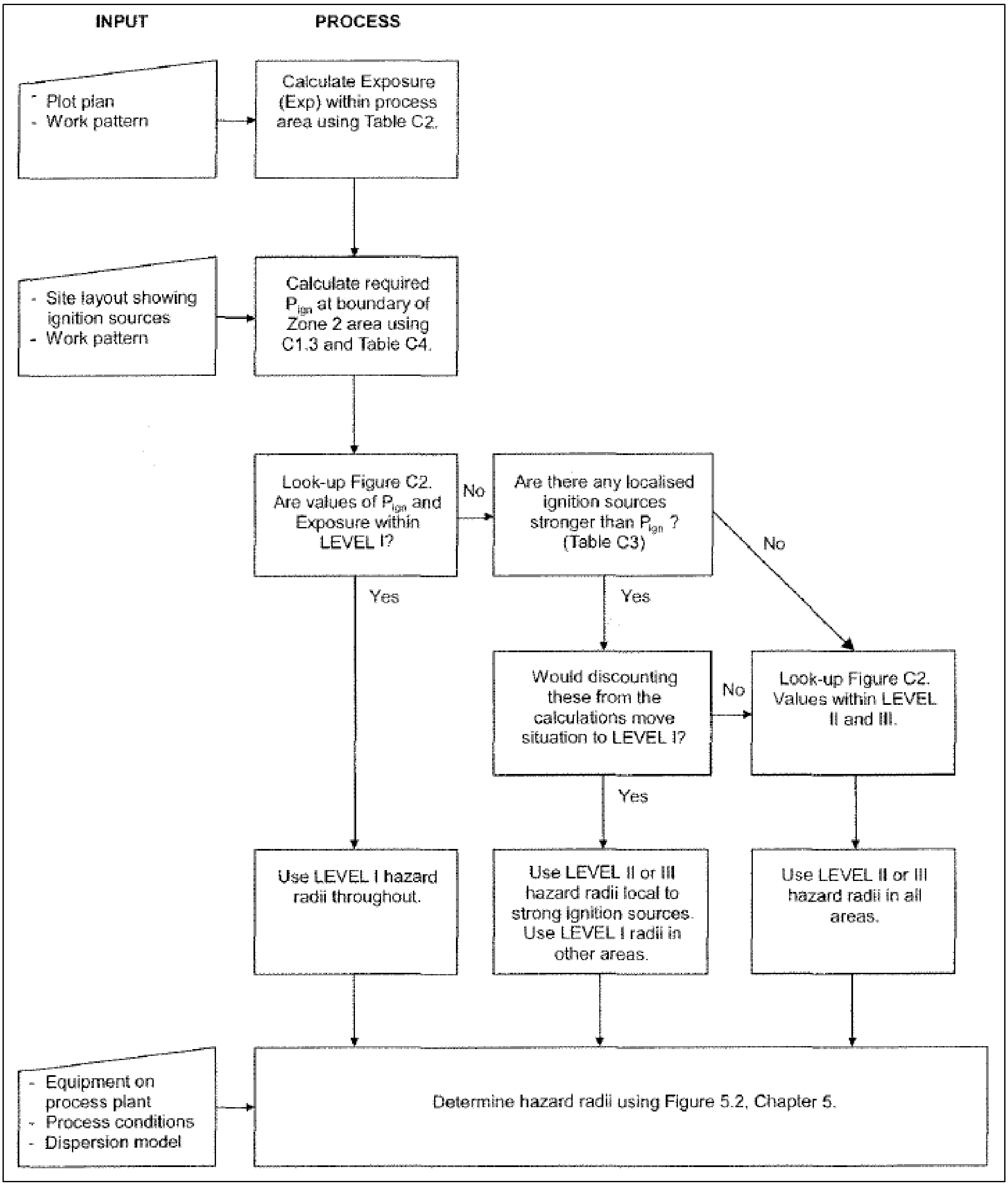


FIGURE 3.3: Methodology for Risk-based approach (IP-15)

3.10 CALCULATION OF EXPOSURE

Workers within Zone 2 hazardous areas are exposed to multiple sources of release, In order to take multiple sources into account a parameter called Exposure (Exp) is used as follows:

$$\mathbf{Exp = P_{occ}\ X\ N_{range}}$$

$\mathbf{P_{occ}}$ = Probability the worker is on site within the hazardous area

$\mathbf{N_{range}}$ = the time weighted average number of release sources which can affect the individual during their time within the hazardous area.

3.10.1 Probability of occupancy (P_{occ})

$\mathbf{P_{occ}}$ is calculated by estimating the proportion of time the individual spends on site exposed to at least one potential release source (i.e. within a hazardous area). This is simply the number of hours the individual spends in the hazardous area per year divided by the number of hours in a year. A maximum number of working hours of 1920 hr/yr. (i.e. 40 hours * 48 weeks) is taken. This corresponds to a maximum $\mathbf{P_{occ}}$ of 0.22 i.e. 1920/8760.

Four values of $\mathbf{P_{occ}}$ are selected for Zone 2:

- 100 % of time on all shifts in a hazardous area ($\mathbf{P_{occ}}$ = 0.22)
- An average of approximately five hr/day in a hazardous area ($\mathbf{P_{occ}}$ = 0.13)
- An average of two hr/day in a hazardous area ($\mathbf{P_{occ}}$ = 0.055)
- An average of one hr/day in a hazardous area ($\mathbf{P_{occ}}$ = 0.028)

3.10.2 Calculation of no. of secondary grade release sources within range (N_{range})

Plant workers will be exposed to a wide variety of potential secondary grade release sources depending on the type of plant and their working schedule. At one extreme there may be workers who spend very short periods of time near hazardous release sources and at the other extreme there will be workers permanently stationed within the hazard ranges of multiple release sources.

To take account of these situations it is necessary to calculate the average number of release sources which could affect the individual.

Table 3.6 Exposure calculation for plant area (IP-15)

Work pattern				No. of release sources within range			
				% of time			N_{range}
Average hours/yr spent on site	Fraction of time on site spent within plant area*	Hours/yr spent on site within radius of plant area	P_{occ} Fraction of total time per yr spent within plant area	**Open plant 1 source**	**Congested plant 5 sources**	**Many release sources 30 sources**	Average number of sources in range during time on site
1920	1	1920	**0,220**	0%	0%	100%	**30**
1920	1	1920	**0,220**	20%	30%	50%	**16,7**
1920	1	1920	**0,220**	20%	50%	30%	**11,7**
1920	1	1920	**0,220**	50%	30%	20%	**8**
1920	1	1920	**0,220**	100%	0%	0%	**1**
1920	0,6	1152	**0,130**	0%	0%	100%	**30**
1920	0,6	1152	**0,130**	20%	30%	50%	**16,7**
1920	0,6	1152	**0,130**	20%	50%	30%	**11,7**
1920	0,6	1152	**0,130**	50%	30%	20%	**8**
1920	0,6	1152	**0,130**	100%	0%	0%	**1**
1920	0,25	480	**0,055**	0%	0%	100%	**30**
1920	0,25	480	**0,055**	20%	30%	50%	**16,7**
1920	0,25	480	**0,055**	20%	50%	30%	**11,7**
1920	0,25	480	**0,055**	50%	30%	20%	**8**
1920	0,25	480	**0,055**	100%	0%	0%	**1**
1920	0,125	240	**0,028**	0%	0%	100%	**30**
1920	0,125	240	**0,028**	20%	30%	50%	**16,7**
1920	0,125	240	**0,028**	20%	50%	30%	**11,7**
1920	0,125	240	**0,028**	50%	30%	20%	**8**
1920	0,125	240	**0,028**	100%	0%	0%	**1**

3.11 PROBABILITY OF IGNITION (P_{ign})

The probability of ignition for a release is taken from the following table

Table 3.7 Probability of ignition (P_{ign}) for varying sources of ignition strength (IP-15)

Source of Ignition	**Description**	**Probability of ignition**
Controlled	Where control of sources of ignition extends beyond Zone 2	0.003
Weak	Typical sources of ignition within a Zone 2 area	0.01
Medium	Ignition due to road traffic, substations, buildings, engines, hot surfaces etc.	0.1
Strong	Continuous strong sources of ignition such as fired heaters, flares etc.	1

3.12 DETERMINATION OF RELEASE FREQUENCY LEVEL AND HOLE SIZE

The release frequency level is found by plotting the values of Exposure and Probability of ignition in the given graph and the levels are selected. With the levels selected the equivalent hole size are taken from examining failure data for various items of equipment considered to be point release sources in this Code. The extent of the flammable atmosphere depends on the size (diameter) of the hole in the equipment and the characteristics of the process fluid.

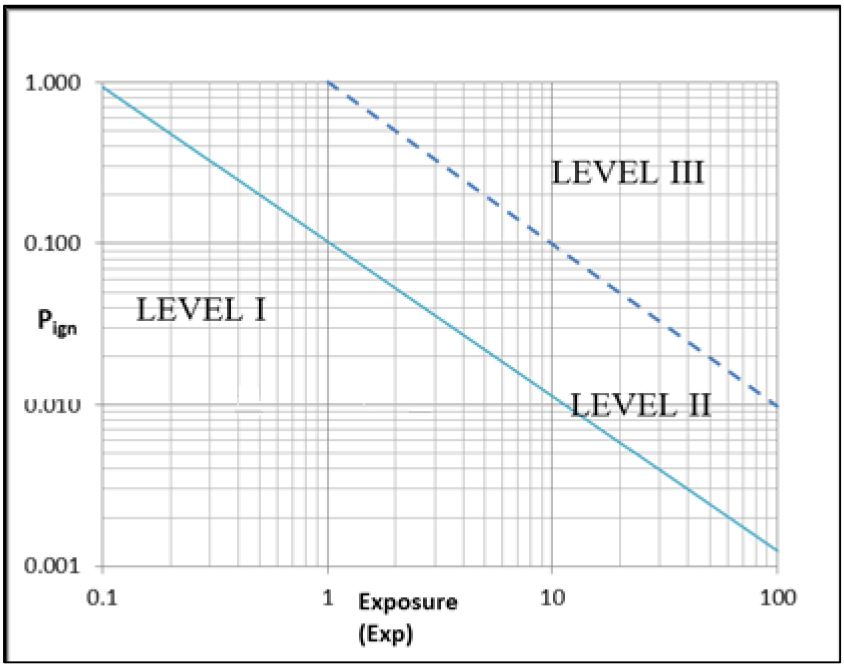


FIGURE 3.4: Release frequency Level Graph (IP-15)

Equipment type	Release frequency level		
	LEVEL I	LEVEL II	LEVEL III
Pumps			
Single seal throttle bush	0,1SD	0,01A or 0,1SD or D*	0,1A
Single seal no throttle bush	0,23SD	0,01A or 0,23SD or D*	
Double seal throttle bush	N/A	0,01A or 0,1SD or D*	
Compressors			
Purged labyrinth	0,12SD	22 mm	70 mm
Floating ring	0,053SD		
Flange (upper bound)	0,6 mm	2,0 mm	6,0 mm
Compressed asbestos fibre	N/A	0,5 mm	2,3 mm
Spiral wound joint	N/A	0,2 mm	0,5 mm
Ring type joint	N/A	0,1 mm	1,0 mm
Valves	0,1 mm	2 mm	0,1DP
Other	Hole size distribution versus frequency to be determined using historical leak data if available, or suitable synthesis technique e.g. fault trees.		

Figure 3.5: Equivalent hole sizes for a range of release frequencies (IP-15)

4.5 DETERMINATION OF HAZARD RADII

The determined fluid category and the hole size extracted from the tables with the operating pressure of equipment are taken as inputs to get the hazard radius for both Upper bound hazard radii (R1) and the ground effect radius (R2)

Table 3.8: Upper Bound Hazard Radii (R1)

Fluid category	Release pressure (bar(a))	Hazard radius R_1 (m) Release hole diameter 1 mm	2 mm	5 mm	10 mm
A	5*	2	4	8	14
	10	2,5	4	9	16
	50	2,5	5	11	20
	100	2,5	5	11	22
B	5	2	4	8	14
	10	2	4	9	16
	50	2	4	10	19
	100	2	4	10	20
C	5	2	4	8	14
	10	2,5	4,5	9	17
	50	2,5	5	11	21
	100	2,5	5	12	22
G(i)	5	< 1	< 1	<1	1,5
	10	< 1	< 1	1	2
	50	< 1	1	2,5	5
	100	< 1	1,5	4	7

Table 3.9 Ground Effect Radius (R2)

Fluid category	Release pressure (bar(a))	Hazard radius R_2 (m) Release hole diameter 1 mm	2 mm	5 mm	10 mm
A	5*	2	4	16	40
	10	2,5	4,5	20	50
	50	3	5,5	20	50
	100	3	6	20	50
B	5	2	4	14	40
	10	2,5	4	16	40
	50	2,5	5	17	40
	100	3	5	17	40
C	5	2,5	4	20	50
	10	2,5	4,5	21	50
	50	3	5,5	21	50
	100	3	6	21	50
G(i)	5	< 1	< 1	1	2
	10	< 1	< 1	1,5	3
	50	< 1	1,5	3,5	7
	100	1	2	5	11

CHAPTER 4: RESULTS & DISCUSSION

4.1 DETERMINATION OF FLUID CATEGORY

- The fluid category is given by the state of the liquid present equipment.
- The state and composition of the crude oil in the equipments are taken from Heat and Mass balance sheet provided by process department of the company and the category is given as per IP-15 standard.

Table 4.1: Determination of Fluid Category

Equipment	**Composition**	**Fluid State (L/G)**	**Fluid Category**
Pig Receiver	Methane-51.6 % C_2 to C_4 - 6.2%	G	G(i)
	C_5 to C_{10} - 11.7% H_2O - 29.8%	L	C
Finger Type Slug Catcher	Methane-51.6 % C_2 to C_4 - 6.2%	G	G(i)
	C_5 to C_{10} - 11.7% H_2O - 29.8%	L	C
Low Pr. Separator	Methane-19.9 % C_2 to C_4 - 3.7%	G	G(i)
	C_5 to C_{10} - 21.7% H_2O - 55%	L	C
Gas Scrubber	Methane-88.4 % C_2 to C_4 - 9.4%	G	G(i)
	C_5 to C_{10} - 1.15% H_20- 0.53%	L	C
Pre-Heat Exchanger	Methane-2.5 % C_2 to C_4- 3.01%	G	G(i)
	C_5 to C_{10} - 37.47% H_2O - 56%	L	B
Heater Treater	Methane-2.5 % C_2 to C_4 - 3.01%	G	G(i)
	C_5 to C_{10} - 37.47% H_2O - 56%	L	B
Degassing Boot	Methane - 1.3 % C_2 to C_4 - 1.1%	G	G(i)
	C_5 to C_{10} - 92.32% H_2O - 1.5%	L	C
Skimmer Unit/ CFU	C_6 to C_{10} - 2.2% H_2O - 97.8%	L	C

4.2 DETERMINATION OF VENTILATION

- Ventilation is determined by finding the placement of equipment
- Here the equipments are in open areas and so the ventilation obtained is Natural ventilation
- The wind speed is greater than 2m/s and having 12 different speeds per day as give per standard so the degree of ventilation is adequate.

Table 4.2: Determination of Ventilation

Equipment	**Ventilation**		
	Area of Ventilation	**Type of Ventilation**	**Degree of Ventilation**
Pig Receiver	Open Area	Natural	Adequate
Finger Type Slug Catcher	Open Area	Natural	Adequate
Low Pr. Separator	Open Area	Natural	Adequate
Gas Scrubber	Open Area	Natural	Adequate
Pre-Heat Exchanger	Open Area	Natural	Adequate
Heater Treater	Open Area	Natural	Adequate
Degassing Boot	Open Area	Natural	Adequate
Skimmer Unit/CFU	Open Area	Natural	Adequate

4.3 DETERMINATION OF GRADE OF RELEASE AND ZONE CLASSIFICATION

- The source of release is taken from P&ID's of respective equipments
- The grade of release is determined by their likely frequency and duration and IP-15 standard
- The Zone is given by considering ventilation and grades of release

Table 4.3: Determination of Grade of release and Zone classification

Equipment	**Sources of Release**	**Grade of Release**	**Zone Classification (0/1/2)**
Pig Receiver	Flanges/Valves	Primary	Zone 1
Finger Type Slug Catcher	Flanges/Valves	Secondary	Zone 2
Low Pr. Separator	Flanges/Valves/SP	Secondary	Zone 2
Gas Scrubber	Flanges/Valves	Secondary	Zone 2
Pre-Heat Exchanger	Flanges/Valves	Secondary	Zone 2
Heater Treater	Flanges/Valves	Secondary	Zone 2
Degassing Boot	Flanges/Valves	Secondary	Zone 2
Skimmer Unit/ CFU	Flanges/Valves/SP	Secondary	Zone 2

4.4 DETERMINATION OF APPARATUS SUB GROUP & TEMPERATURE CLASS

- The Apparatus sub group is taken from the IP-15 standard for the respective hydrocarbons
- The temperature class is taken from IP-15 standard with respective Auto-Ignition Temperature

Table 4.4: Determination of Apparatus sub group & Temperature class

Equipment	Composition	Auto-Ignition Temperature (°C)	Apparatus Sub Group	Temperature Class
Pig Receiver	Methane-51.6 % C_2 to C_4 - 6.2%	365	IIA	T3
	C_5 to C_{10} - 11.7% H_2O - 29.8%	205		
Finger Type Slug Catcher	Methane-51.6 % C_2 to C_4 - 6.2%	365	IIA	T3
	C_5 to C_{10} - 11.7% H_2O - 29.8%	205		
Low Pr. Separator	Methane-19.9 % C_2 to C_4 - 3.7%	365	IIA	T3
	C_5 to C_{10} - 21.7% H_2O - 55%	205		
Gas Scrubber	Methane-88.4 % C_2 to C_4 - 9.4%	365	IIA	T3
	C_5 to C_{10} - 1.15% H_20- 0.53%	205		
Pre-Heat Exchanger	Methane-2.5 % C_2 to C_4- 3.01%	365	IIA	T3
	C_5 to C_{10} - 37.47% H_2O - 56%	205		
Heater Treater	Methane-2.5 % C_2 to C_4 - 3.01%	365	IIA	T3
	C_5 to C_{10} - 37.47% H_2O - 56%	205		
Degassing Boot	Methane - 1.3 % C_2 to C_4 - 1.1%	365	IIA	T3
	C_5 to C_{10} - 92.32% H_2O - 1.5%	205		
Skimmer Unit/CFU	C_6 to C_{10} - 2.2% H_2O - 97.8%	205	IIA	T3

4.5 DETERMINATION OF EXPOSURE AND $P_{ignition}$

- The Exposure and $P_{ignition}$ are calculated from the IP-15 standard

Table 4.5: Determination of Exposure and $P_{ignition}$

$Exp = P_{occ} \times N_{range}$

P_{occ} = Probability the worker is on site within the hazardous area

N_{range} = The time weighted average number of release sources which can affect the individual during their time within the hazardous area.

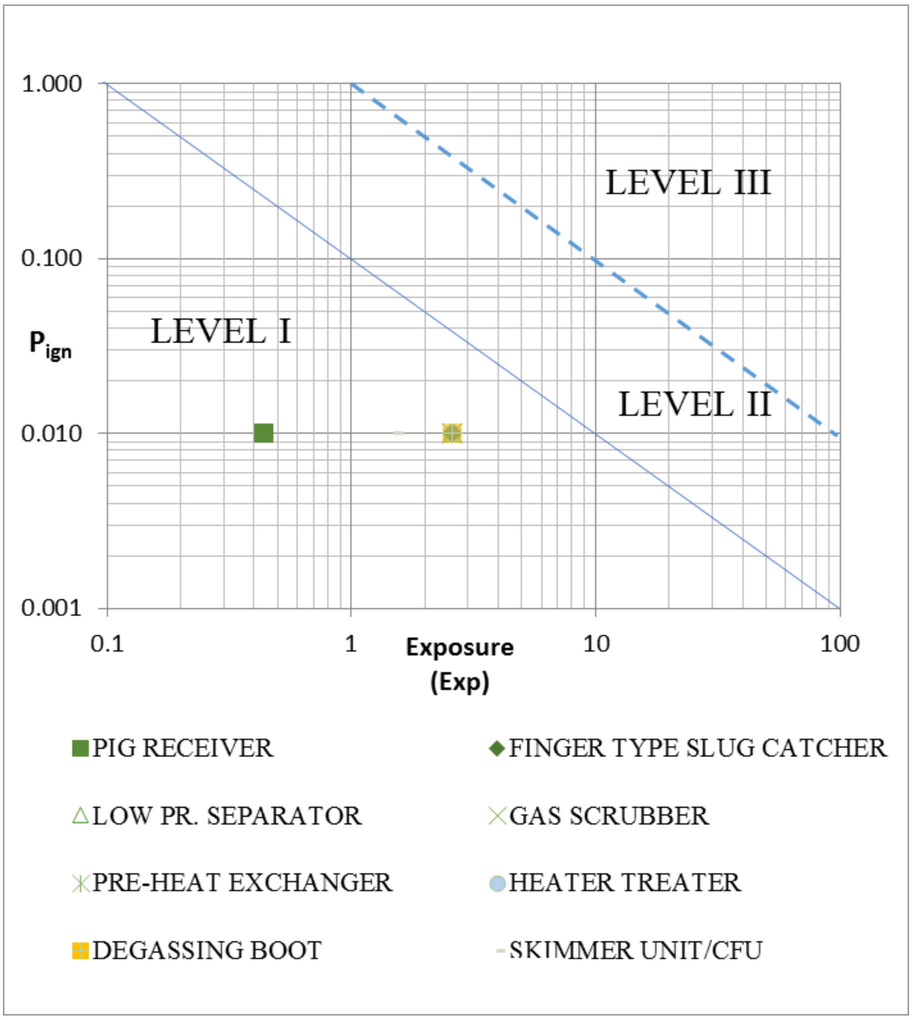
Equipment	P_{occ}	N_{range}	Exp	Equipment	Pignition
Pig Receiver	0.055	8	**0.44**	Pig Receiver	0.010
Finger Type Slug Catcher	0.22	11.7	**2.6**	Finger Type Slug Catcher	0.010
Low Pr. Separator	0.22	11.7	**2.6**	Low Pr. Separator	0.010
Gas Scrubber	0.22	11.7	**2.6**	Gas Scrubber	0.010
Pre-Heat Exchanger	0.22	11.7	**2.6**	Pre-Heat Exchanger	0.010
Heater Treater	0.22	11.7	**2.6**	Heater Treater	0.010
Degassing Boot	0.22	11.7	**2.6**	Degassing Boot	0.010
Skimmer Unit/CFU	0.13	11.7	**1.5**	Skimmer Unit/CFU	0.010

4.6 DETERMINATION OF RELEASE FREQUENCY LEVEL

- The release frequency level is calculated by plotting the Exp & Pign in the chart given in IP-15 standard and the level is found

Table 4.6: Determination of release frequency level

Equipment	Exp	P_{ign}	LEVEL
Pig Receiver	0.44	0.010	I
Finger Type Slug Catcher	2.6	0.010	I
Low Pr. Separator	2.6	0.010	I
Gas Scrubber	2.6	0.010	I
Pre-Heat Exchanger	2.6	0.010	I
Heater Treater	2.6	0.010	I
Degassing Boot	2.6	0.010	I
Skimmer Unit/CFU	1.5	0.010	I



4.7 DETERMINATION OF HOLE SIZE

- From the chart the level is found and the hole size is determined from IP-15 standard

Table 4.7: Determination of hole size

Equipment	Equipment Type	LEVEL	HOLE SIZE
Pig Receiver	Flanges/Valves	I	.6mm
Finger Type Slug Catcher	Flanges/Valves	I	.6mm
Low Pr. Separator	Flanges/Valves/SP	I	.6mm
Gas Scrubber	Flanges/Valves	I	.6mm
Pre-Heat Exchanger	Flanges/Valves	I	.6mm
Heater Treater	Flanges/Valves	I	.6mm
Degassing Boot	Flanges/Valves	I	.6mm
Skimmer Unit/CFU	Flanges/Valves/SP	I	.6mm

4.8 DETERMINATION OF HAZARD RADII

- The Upper bound & ground effect hazard radius are determined from the IP-15 standard

Table 4.8: Determination of Upper bound & ground effect hazard radius

Equipment	Fluid category	Pressure (bar)	Hole size (mm)	Upper bound hazard radii R1 (m)	Ground effect radius R2 (m)
Pig Receiver	G(i)	9	0.6	1	1
	C	9	0.6	2.5	2.5
Finger Type Slug Catcher	G(i)	9	0.6	1	1
	C	9	0.6	2.5	2.5
Low Pr. Separator	G(i)	6.63	0.6	1	1
	C	6.63	0.6	2.5	2.5
Gas Scrubber	G(i)	7.1	0.6	1	1
	C	7.1	0.6	2.5	2.5
Pre-Heat Exchanger	G(i)	5.6	0.6	1	1
	B	5.6	0.6	2.5	2.5
Heater Treater	G(i)	3.9	0.6	1	1
	B	3.9	0.6	2	2
Degassing Boot	G(i)	1.5	0.6	1	1
	C	1.5	0.6	2.5	2.5
Skimmer Unit/ CFU	C	6	0.6	2	2

Table 4.8: Hazardous Area Classification Data Sheet

S.NO	EQUIPMENT	OPERATING PROCESS PARAMETERS			FLUID PROPERTIES			IP-15 CLASSIFICATION			VENTILATION		SOURCE OF RELEASE		ZONE CLASSIFICATION (0/1/2)	HAZARD RADIUS		
		COMPOSITION	TEMPERATURE (°C)	PRESSURE (barg)	FLASH POINT (°C)	AUTO-IGNITION TEMPERATURE (°C)	FLUID STATE (L/G)	FLUID CATEGORY	APPARATUS SUB GROUP	TEMPERATURE CLASS	DEGREE OF VENTILATION	TYPE OF VENTILATION	SOURCES OF RELEASE	GRADE OF RELEASE		HOLE SIZE (mm)	VERTICAL R1 (m)	HORIZONTAL R2 (m)
1	PIG RECEIVER	Methane-51.6 % C_2 to C_4 - 6.2%	31	9	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES	PRIMARY	ZONE 1	0.6	1	1
		C_5 to C_{10} - 11.7% H_2O - 29.8%	31	9	−49.0	205	L	C								0.6	2.5	2.5
2	FINGER TYPE SLUG CATCHER	Methane-51.6 % C_2 to C_4 - 6.2%	31	9	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES	SECONDARY	ZONE 2	0.6	1	1
		C_5 to C_{10} - 11.7% H_2O - 29.8%	31	9	−49.0	205	L	C								0.6	2.5	2.5
3	LOW PR. SEPARATOR	Methane-19.9 % C_2 to C_4 - 3.7%	31	6.63	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES/SP	SECONDARY	ZONE 2	0.6	1	1
		C_5 to C_{10} - 21.7% H_2O - 55%	31	6.63	−49.0	205	L	C								0.6	2.5	2.5
4	GAS SCRUBBER	Methane-88.4 % C_2 to C_4 - 9.4%	30	7.1	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES	SECONDARY	ZONE 2	0.6	1	1
		C_5 to C_{10} - 1.15% H_20- 0.53%	30	7.1	−49.0	205	L	C								0.6	2.5	2.5
5	PRE-HEAT EXCHANGER	Methane-2.5 % C_2 to C_4- 3.01%	48	5.6	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES	SECONDARY	ZONE 2	0.6	1	1
		C_5 to C_{10} - 37.47% H_2O - 56%	48	5.6	−22.0	205	L	B								0.6	2.5	2.5
6	HEATER TREATER	Methane-2.5 % C_2 to C_4 - 3.01%	60	3.9	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES	SECONDARY	ZONE 2	0.6	1	1
		C_5 to C_{10} - 37.47% H_2O - 56%	60	3.9	−22.0	205	L	B								0.6	2.5	2.5
7	DEGASSING BOOT	Methane - 1.3 % C_2 to C_4 - 1.1%	31	1.5	–	365	G	G(i)	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES	SECONDARY	ZONE 2	0.6	1	1
		C_5 to C_{10} - 92.32% H_2O - 1.5%	31	1.5	−22.0	205	L	C								0.6	2.5	2.5
8	SKIMMER UNIT/ CFU	C6 to C_{10} - 2.2% H_2O - 97.8%	48	6	−22.0	205	L	C	IIA	T3	ADEQUATE	NATURAL	FLANGES/VALVES/SP	SECONDARY	ZONE 2	0.6	2	2

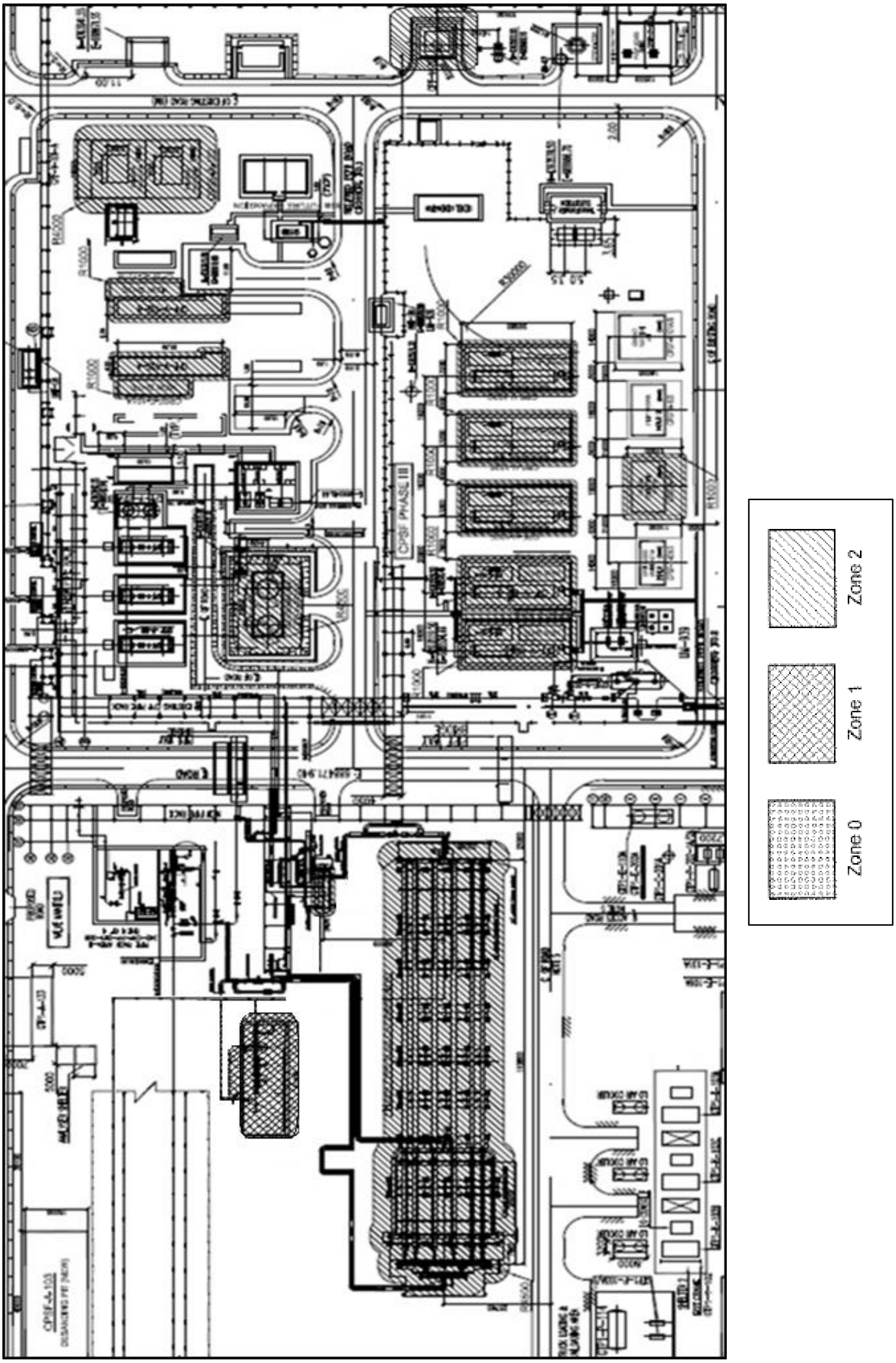


Figure 4.1: Layout of Hazardous Area Classification for Central Processing Facility

CHAPTER 5: SUMMARY & CONCLUSIONS

5.1 SUMMARY OF PROJECT

- The detailed Hazardous Area Classification study of a Central processing facility have proven that the equipments can be classified into Zones that can prevent the ignition of any flammable release which may occur by the electrical and mechanical equipment installed in the facility.
- Thus proper protection for electrical and mechanical equipment will be given according to zones where it is installed.

5.2 CONCLUSION OF PROJECT

- Thus zone 1 is classified for Pig receiver as it is considered as a primary source of release.
- Zone 2 is classified for the other equipments as the ventilation is adequate and the grade of release is secondary.
- The hazard radius is marked to the circumference of the equipments as it is tedious o mark for every single point of release.
- The Zone 1 type protections are
  - **Flame-proof enclosure (Ex d)**
  - **Increased safety (Ex e)**
  - **Encapsulation type of protection (Ex m)**
  - **Intrinsic safety (Ex ia and Ex ib)**
- The Zone 2 type protections are
  - **Oil immersed protection (Ex o)**
  - **Powder-filled protection (Ex q)**
  - **Non-incentive (Ex n)**

References

1) IP-15 : Area classification code for installations handling flammable fluids
2) Mannan, Sam, ed. Lees' Loss prevention in the process industries: Hazard identification, assessment and control. Butterworth-Heinemann, 2004.
3) Lakhapate, P. J. "Hazardous area classification." Chemical engineering world 33.3 (1998): 67-70.
4) Corn, Morton, and NURTAN A. ESMEN. "Workplace exposure zones for classification of employee exposures to physical and chemical agents." The American Industrial Hygiene Association Journal 40.1 (1979): 47-57.
5) API 505: Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Zone 0, Zone 1, and Zone 2
6) NFPA 497 : Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas
7) IEC60079-10 : Electrical apparatus for explosive gas atmospheres – Part 10: Classification of hazardous areas

Annexure 1: Definitions

Auto Ignition Temperature (AIT)

The minimum temperature required to initiate or cause self-sustained combustion of a solid, liquid, or gas independently of the heating or heated element.

Boiling Point

The temperature of a liquid boiling at an ambient pressure of 101.3 bar

Combustible Material

A generic term used to describe a flammable gas, flammable liquid produced vapour, or combustible liquid produced vapour mixed with air that may burn or explode.

Flammability Limits

The lower and upper percentages by volume of concentration of gas in a gas air mixture that will form an ignitible mixture.

Flash Point

The minimum temperature at which a liquid gives off vapour in sufficient concentration to form an ignitable mixture with air near the surface of the liquid.

Hazardous Area Classification

Hazardous area classification is the assessed division of a facility into hazardous areas and non-hazardous areas, and the subdivision of the hazardous areas into zones.

Hazardous Location

A location where fire or explosion hazards may exist due to flammable gases or vapour, flammable liquids, combustible dust, or ignitable fibers or flying's. Unless specifically indicated otherwise, locations containing combustible dust, ignitable fibers or flying's are outside the scope of this recommended practice.

Flammable Mixture

A gas-air mixture that is capable of being ignited by an open flame, electric arc or spark, or device operating at or above the ignition temperature of the gas air mixture.

Minimum Ignition Energy (MIE)

The minimum energy required from a capacitive spark discharge to ignite the most easily ignitible mixture of a gas or vapour.

Mist, Flammable

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

Source of Release

A point or location from which a flammable gas, vapour, or liquid may be released into the atmosphere such that an ignitable gas atmosphere could be formed.

Ventilation

Movement of air and its replacement with fresh air due to the effects of wind, temperature gradients, or artificial methods.