# 2nd Chemical Process Safety Sharing (CPSS)

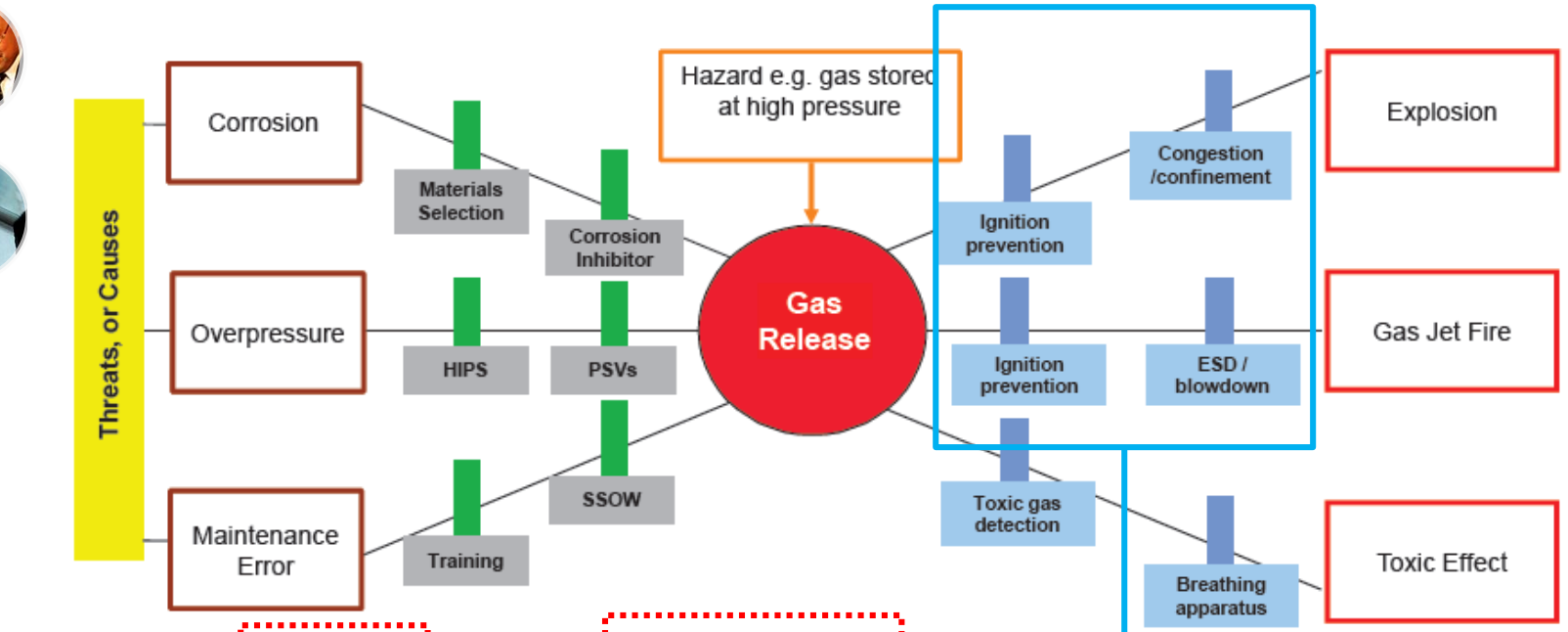
## Points of concern for hazardous area classification

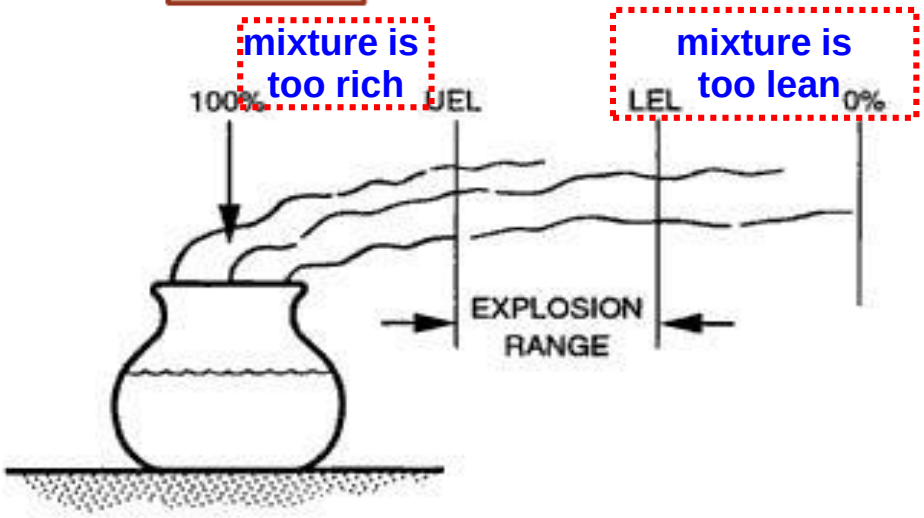
Chawarin Poyomrut
Lead Engineer – Process Safety
SCG Chemicals

# Contents

- Concept of hazardous area classification
- Ventilation vs. Hazardous area classification
- Enclose area with internal source of release
- Enclose area without internal source of release but facing to hazardous area
- Hazardous are for small scale operation

# Concept of hazardous area classification




**Ignition Source Control**

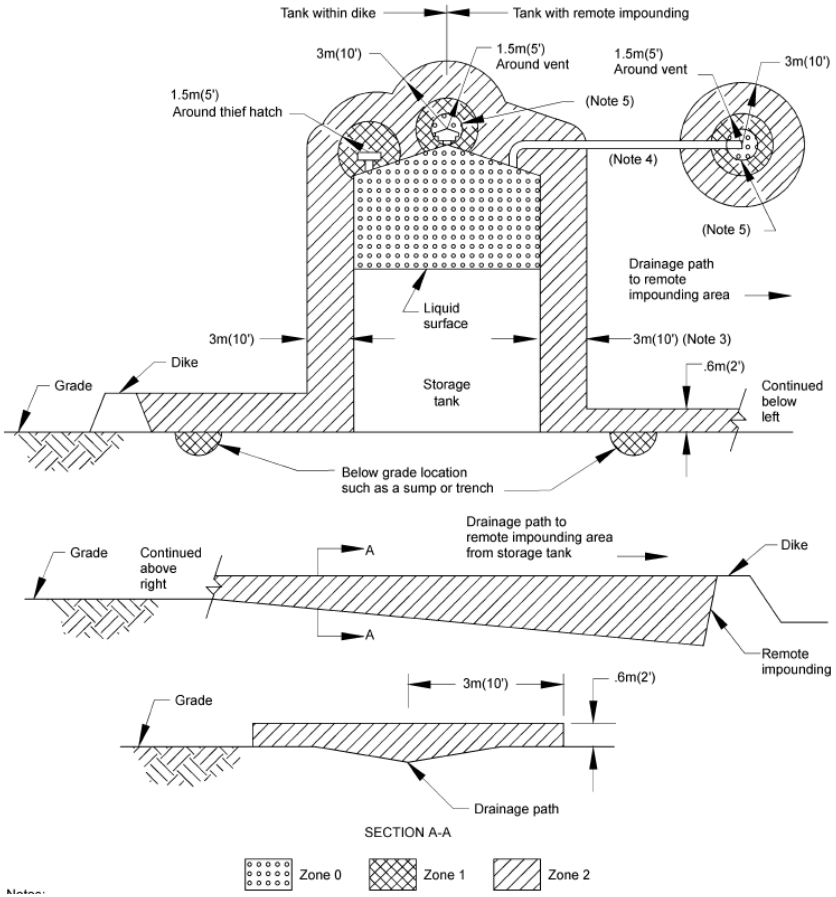
- **Ignition prevention i.e. Electrical classification**
- Gas detection
- ESD system
- Ventilation
- Ground and bonding
- Hot work permit

SCG CHEMICALS

# Concept of hazardous area classification

## Hazardous Area classification shows:

- Where an explosive atmosphere may occur and disperse in air under normal operating conditions.
- Likelihood.
- Which flammable materials may cause an explosive atmosphere.




## Methodology:

**1) Identify point sources and associated release conditions;**

**2) Determine grade of release;**

- Continuous
- Primary
- Secondary

**3) Determine gas group or fluid category;**

- I, IIA, IIB, IIC (IEC) - Zone
- A, B, C, D (NEC) - Division

**4) Define temperature class;**

- T1 – T6

**5) Establish zone classification;**

- Class I Zone 0, Zone 1, Zone 2
- Class I Division 1, Class I Division 2

**6) Determine hazard radii or extent;**

**7) Determine hazardous area, and combine the hazardous areas from different point sources.**

SCG CHEMICALS

# Grade of release vs. Zone classification

## API 505

Table 2—Showing the Relationship Between Grade of Release and the Presence of Flammable Mixtures

| Grade of Release | Flammable Mixture Present |
|---|---|
| Continuous | 1000 or more hours/year |
| Primary | 10 < hours/ year < 1000 |
| Secondary | less than 10 hours/year |

## IE 15

Table 1.2: Relationship of grade of release to zone for an open area

| Grade of release | Likely to occur in normal operation | Presence of flammable atmosphere hours/ yr in open area | Zone |
|---|---|---|---|
| **Continuous** | Yes | Greater than 1 000 | Zone 0 |
| **Primary** | Yes | 1 000 – 10 | Zone 1 |
| **Primary** | Yes | Fewer than 10 | Zone 2 |
| **Secondary** | No | Greater than 10 | Zone 1 |
| **Secondary** | No | Fewer than 10 | Zone 2 |

Similar concept grade of release between API 505 and IE 15

| Grade of release | Zone | Example source of release |
|---|---|---|
| Continuous | Zone 0 | Continuous vent point, Inside storage tank |
| Primary | Zone 1 | Partially vent, atm vent from Zone 1 enclosed area |
| Secondary | Zone 2 | Flange, valve, strainer, mechanical seal, atm vent from Zone 2 enclosed area |

In a congested, stagnant or enclosed area, a more stringent zone may apply.

SCG CHEMICALS

# Zone vs. Division

| Material | API 500, NFPA 497 NEC | API 505, NFPA 497, IE 15 IEC | |
|---|---|---|---|
| Flammable liquid, Gas and Vapor | Class I Div. 1 | Class I Zone 0 | Zone 0 |
| | | Class I Zone 1 | Zone 1 |
| | Class I Div. 2 | Class I Zone 2 | Zone 2 |
| Combustible dust NFPA 499, NFPA 654 | Class II Div. 1 | Class II Zone 20 | Zone 20 |
| | | Class II Zone 21 | Zone 21 |
| | Class II Div. 2 | Class II Zone 22 | Zone 22 |

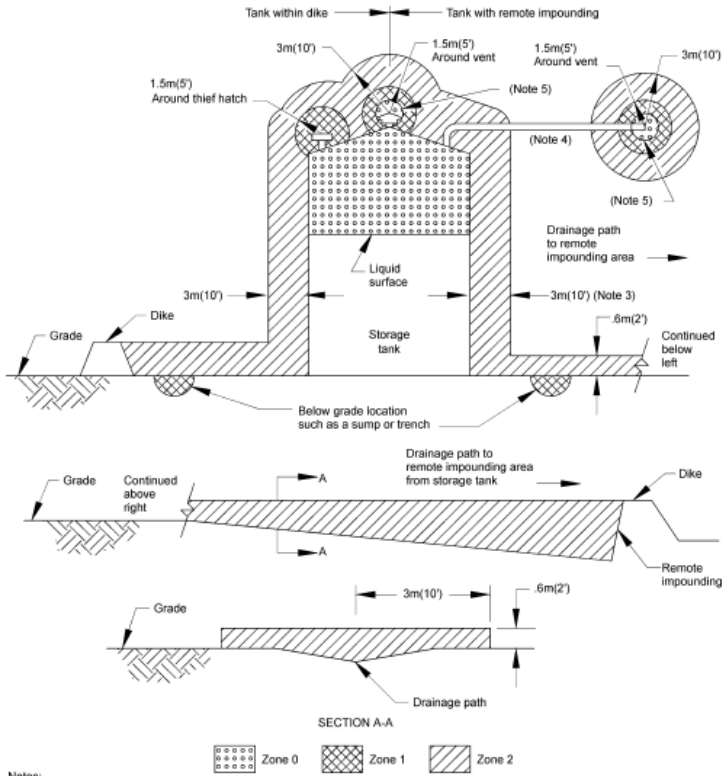
| Class I | Division system | Description | Zone system | Comment |
|---|---|---|---|---|
| Flammable liquid, Gas and Vapor | Div. 1 | Hazardous under normal operation | Zone 0<br>Zone 1 | Div.1 is split into Zone 0 and 1. Zone 0 is a small percentage of location usually confined to inside vented tanks or continuous atm vent. |
| | Div. 2 | Not normally hazardous | Zone 2 | Flange, Mechanical seal |

SCG CHEMICALS

# Hazardous extent or radii

## API 505

### Code based approach




## IE 15

### Risk based approach

- Release Frequency Level
  - Exposure
  - Likelihood of ignition
- Release Frequency Level
- Type of equipment/ mechanical seal
  - Release hole size
- DNV Phast dispersion modelling at 70% LFL

Table C4: Hazard radii $R_1$ and $R_2$ for pressurised releases

| Fluid category | Release pressure see note 4 (bar(a)) | Hazard radius $R_1$ (m) | | | | Hazard radius $R_2$ (m) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Release hole diameter | | | | Release hole diameter | | | |
| | | 1 mm | 2 mm | 5 mm | 10 mm | 1 mm | 2 mm | 5 mm | 10 mm |
| A | 5 | 2 | 4 | 8 | 14 | 2 | 4 | 16 | 40 |
| | 10 | 2,5 | 4 | 9 | 16 | 2,5 | 4,5 | 20 | 50 |
| | 50 | 2,5 | 5 | 11 | 20 | 3 | 5,5 | 20 | 50 |
| | 100 | 2,5 | 5 | 11 | 22 | 3 | 6 | 20 | 50 |
| B | 5 | 2 | 4 | 8 | 14 | 2 | 4 | 14 | 40 |
| | 10 | 2 | 4 | 9 | 16 | 2,5 | 4 | 16 | 40 |
| | 50 | 2 | 4 | 10 | 19 | 2,5 | 5 | 17 | 40 |
| | 100 | 2 | 4 | 10 | 20 | 3 | 5 | 17 | 40 |

**Hazardous area extent of IE 15 often smaller than API 505**

SCG CHEMICALS

# Gas group mixture

In principle: The most hazardous substance determines the gas group of mixture.

However:

- IE 15: Mixture contains $H_2$ > 15 % Vol. -> group IIC
- NFPA 497 Annex B: *NEC* group classification of a mixture

[B.1a]

$$MESG_C(T) = \frac{1}{\sum_{i=1}^{n} \Sigma \frac{x_{O_2}^{(i)}}{MESG_i(T)}}$$

where:

$MESG_c(T)$ = Calculated maximum experimental safe gap of mixture at temperature $T$, mm

$MESG_i(T)$ = Maximum experimental safe gap of component $i$ of mixture at temperature $T$ (mm)

$x_{O_2}^{(i)}$ = Relative amount of oxygen necessary for stoichiometric reaction of component $i$

**Table B.1 Physical Properties of Selected Materials**

| | Mol. Wt. | S (Oxygen to Fuel Molar Ratio) | MESG (mm) | NEC Group |
|---|---|---|---|---|
| Methane | 16.04 | 2 | 1.12 | D |
| Hydrogen | 2.01 | 0.5 | 0.28 | B |
| Propane | 44.10 | 5 | 0.97 | D |
| Nitrogen | 28.01 | NA | NA | NA |
| Oxygen | 32 | NA | NA | NA |

**3.3.9 Maximum Experimental Safe Gap (MESG).** The maximum clearance between two parallel metal surfaces that has been found, under specified test conditions, to prevent an explosion in a test chamber from being propagated to a secondary chamber containing the same gas or vapor at the same concentration.

SCG CHEMICALS

# Classification of liquid

## API 505/ NFPA 497

- Applicable for Class I Flammable liquid only
- Not applicable for Class II and Class III Combustible liquids:
  - Low probability of an ignitable vapor-air mixture
  - Not to be considered for electrical classification purposes.

1) Volatile flammable liquid: Class II combustible liquid having a vapor pressure not exceeding 276 kPa (40 psia) at 37.8°C (100°F) whose temperature is above its flash point.
2) When these liquids are heated above their flash point, additional vapors are generated, and the probability of ignition is increased.

IE 15 consider combustible liquid (Class II, III) classified and unclassified liquid if:

- Handling above flash point + above boiling point
- Can be leased as mist
- Handling above flash point but below boiling point and cannot be released as mist

## IE 15

Table A3: Relationship between EI petroleum class and fluid category

| IP Petroleum class, based (except for LPG) on closed cup flash points | | | Fluid category | | |
|---|---|---|---|---|---|
| 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[3] |
| 0 | Liquefied petroleum gases (LPG) | Yes | A | A | A[2] |
| I | Flash point less than 21 °C | Yes | B | C | C |
| II(1) | Flash point 21 – 55 °C | No | N/A[1] | C | N/A[1] |
| II(2) | Flash point 21 – 55 °C | Yes | B | C | C |
| III(1) | Flash point 55 – 100 °C | No | N/A[1] | C | N/A[1] |
| III(2) | Flash point 55 – 100 °C | Yes | B | C | C |
| Unclassified(1) | Flash point greater than 100 °C | No | N/A[1] | C | N/A[1] |
| Unclassified(2) | Flash point greater than 100 °C | Yes | B | C | C |

Notes

1. Not applicable (N/A) because liquids not handled above their flash point cannot be above their boiling point.
2. Cryogenic fluids need special consideration.
3. See A1.2 for mists and sprays.

SCG CHEMICALS

# Enclosed area with internal leak source

## API 505

Table F-1— Influence of Ventilation on Zone Classification

| Grade of Release | Ventilation | | | | | | |
|---|---|---|---|---|---|---|---|
| | Degree | | | | | | |
| | High | | | Medium | | | Low |
| | Availability | | | | | | |
| | Good | Fair | Poor | Good | Fair | Poor | Good, Fair or Poor |
| Continuous | (Zone 0 NE) Non-Hazardous[1] | (Zone 0 NE) Zone 2[1] | (Zone 0 NE) Zone[1] | Zone 0 | Zone 0 + Zone 2 | Zone 0 + Zone 1 | Zone 0 |
| Primary | (Zone 1 NE) Non-Hazardous[1] | (Zone 1 NE) Zone 2[1] | (Zone 1 NE) Zone 2[1] | Zone 1 | Zone 1 + Zone 2 | Zone 1 + Zone 2 | Zone 1 or Zone 0[3] |
| Secondary[2] | (Zone 2 NE) Non-Hazardous[1] | (Zone 2 NE) Non-Hazardous[1] | Zone 2 | Zone 2 | Zone 2 | Zone 2 | Zone 1 and even Zone 0[3] |

[1]Zone 0 NE, 1 NE or 2 NE indicates a theoretical zone that would be of negligible extent under normal conditions.

[2]The Zone 2 area created by a secondary grade of release may exceed that attributable to a primary or continuous grade of release, in which case, the greater distance should be taken.

[3]Will be Zone 0 if the ventilation is so weak and the release is such that in practice an explosive atmosphere exists virtually continuously (i.e., approaching a "no ventilation" condition).

Note: "+" signifies "surrounded by."
Zone 0", "Zone 1", and "Zone 2" are understood to be preceded by "Class 1."

**Adequately ventilated outdoor environment**

**High ventilation leads to reduction of Zone classification in enclosed area or semi-enclosed.**

SCG CHEMICALS

# Enclosed area with internal leak source

## IE 15

| Grade of internal release source | Ventilation | | | |
|---|---|---|---|---|
| | Inadequate[1] | Adequate[1] | | Over-pressure |
| | | Zoning local to source[3] | Zoning of remaining enclosed area[3] | |
| Continuous | Avoid[2] | Zone 0 | Zone 1 | Not applicable where there is an internal primary or continuous grade of release, but may be applicable in conjunction with adequate ventilation to maintain an enclosed area containing only secondary grade releases as Zone 2 when surrounded by a Zone 0 or 1 hazardous area. |
| Primary | Avoid[2] | Zone 1 | Zone 2 | |
| Secondary | Zone 1 | Zone 2 | none | |

Notes:

1. Adequate ventilation means that the ventilation rate as given in section 4.3.1.1 is sufficient to apply the zone classification appropriate for that grade of release.
2. Location of continuous or primary grade sources within an inadequately ventilated enclosed area should be avoided. If it is unavoidable, engineering controls such as local exhaust ventilation must be provided.
3. With a source of small hazard radius, e.g. a sample point, the ventilation locally can sometimes be high enough to prevent the source influencing the classification of the enclosure as a whole. The extent of the zones around sources of release should be determined taking into account the background concentration within the enclosure. As a rule of thumb (when maintaining <25 % LFL) the extent of the hazardous area given in Table C4 for an outdoor release should be multiplied be a factor of 2, unless other precise methodologies are used.

**IE 15 is not recommended inadequate ventilation for continuous and primary grade of release. Engineering controls (e.g. local ventilation) must be provided.**

SCG CHEMICALS

# Adequate ventilation

## API 505/ NFPA 497

Adequate ventilation: Air movement to achieve 25 % LEL

- 6 air changes/hr -> Minimum for enclosed area
- 12 air changes/hr -> Naturally ventilated enclosed areas
- Appendix A: Calculation to achieve adequate ventilation

## IE 15

Adequate ventilation: Air movement to achieve 25 % LEL

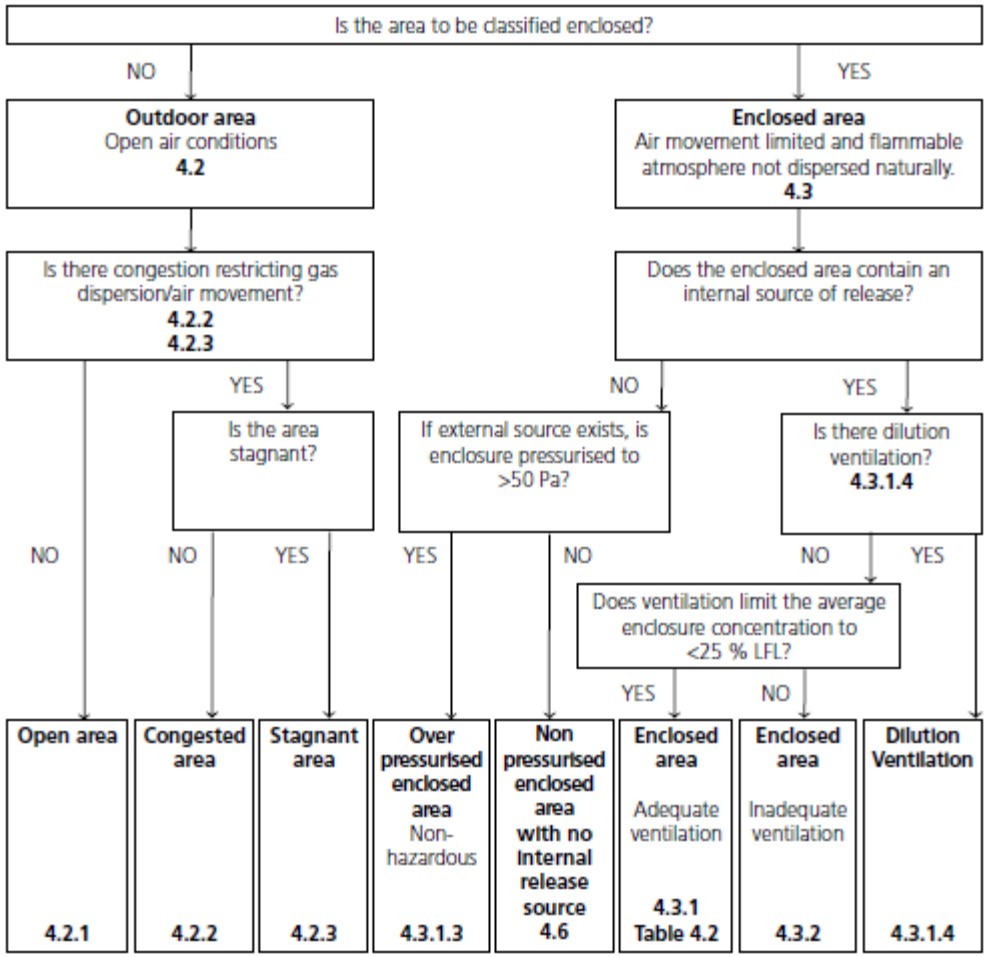



**Figure 4.1: Procedure for assessing type and degree of ventilation**

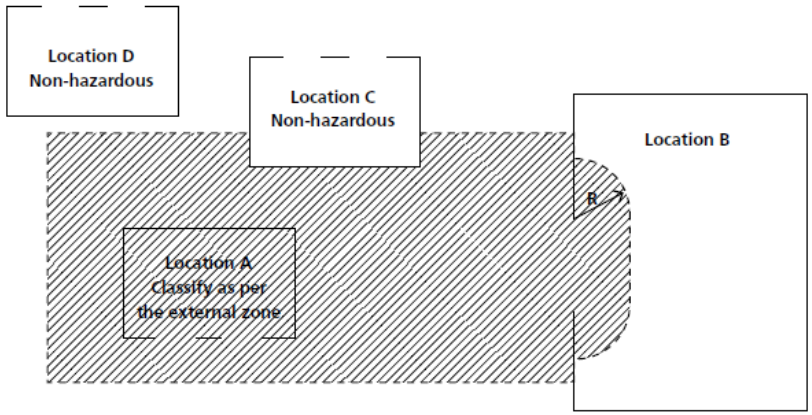
# Non-hazardous enclosed area located in outdoor hazardous area

## API 505/ NFPA 497/ IEC 60079-13

Enclosed area facing hazardous zone

- Ventilation of inlet from unclassified location
- Alarm when loss of ventilation
- Air lock door with 6 ACs/hr
- Positive pressure -> 25 Pa
- Vapor tight door
- Self-closing door
- No window

## IE 15




Notes:

| | | |
|---|---|---|
| Location A | Enclosed area within hazardous area. | Classify enclosed area as per the external zone. |
| Location B | Enclosed area with a portion of the perimeter with openings within a hazardous area. | See four options described in 4.6. |
| Location C | Enclosed area with no openings within the hazardous area and the portion of the enclosed area within the hazardous area is gas tight. | Classify as non-hazardous. |
| Location D | Enclosed area located in a non-hazardous area. | Classify as non-hazardous. |

**Figure 4.4: Enclosed areas without an internal source of release located within or adjacent to classified areas**

SCG CHEMICALS

# Layout vs. hazardous area

## NFPA 30

Safety distances in NFPA 30 is alighted with NFPA 497 and API 505.

Δ Table 17.4.3 Location of Process Vessels with Respect to Property Lines, Public Ways, and the Nearest Important Building on the Same Property — Protection for Exposures Is Provided

| | Minimum Distance (ft) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | From Property Line that Is or Can Be Built upon, Including Opposite Side of Public Way | | | | From Nearest Side of Any Public Way or from Nearest Important Building on Same Property that Is Not an Integral art of the Process | | | |
| | Stable Liquid Emergency Relief* | | Unstable Liquid Emergency Relief* | | Stable Liquid Emergency Relief* | | Unstable Liquid Emergency Relief* | |
| Vessel Maximum Operating Liquid Capacity (gal) | Not Over 2.5 psi | Over 2.5 psi | Not Over 2.5 psi | Over 2.5 psi | Not Over 2.5 psi | Over 2.5 psi | Not Over 2.5 psi | Over 2.5 psi |
| 275 or less | 5 | 25 | 50 | 100 | 5 | 25 | 50 | 100 |
| 276 to 750 | 10 | 25 | 50 | 100 | 5 | 25 | 50 | 100 |
| 751 to 12,000 | 15 | 25 | 50 | 100 | 5 | 25 | 50 | 100 |
| 12,001 to 30,000 | 20 | 30 | 50 | 100 | 5 | 25 | 50 | 100 |
| 30,001 to 50,000 | 30 | 45 | 75 | 120 | 10 | 25 | 50 | 100 |
| 50,001 to 100,000 | 50 | 75 | 125 | 200 | 15 | 25 | 50 | 100 |
| Over 100,000 | 80 | 120 | 200 | 300 | 25 | 40 | 65 | 100 |

For SI units, 1 gal = 3.8 L; 1 ft = 0.3 m; 1 psi = a gauge pressure of 6.9 kPa.
Note: Double all of above distances where protection for exposures is not provided.
*Gauge pressure.

Δ Table 7.3.3 Electrical Area Classifications

| | *NEC* Class I | | |
|---|---|---|---|
| Location | Division | Zone | Extent of Classified Area |
| Indoor equipment installed in accordance with Section 7.3 where flammable vapor–air mixtures can exist under normal operation | 1 | 0 | The entire area associated with such equipment where flammable gases or vapors are present continuously or for long periods of time |
| | 1 | 1 | Area within 5 ft of any edge of such equipment, extending in all directions |
| | 2 | 2 | Area between 5 ft and 8 ft of any edge of such equipment, extending in all directions; also, space up to 3 ft above floor or grade level within 5 ft to 25 ft horizontally from any edge of such equipment[1] |

SCG CHEMICALS

# Hazardous area for small scale operation

## Laboratory:

- **NFPA 45:** Standard on Fire Protection for Laboratories Using Chemicals
- **NFPA 496:** Standard for Purged and Pressurized Enclosures for Electrical Equipment

## Pilot plant:

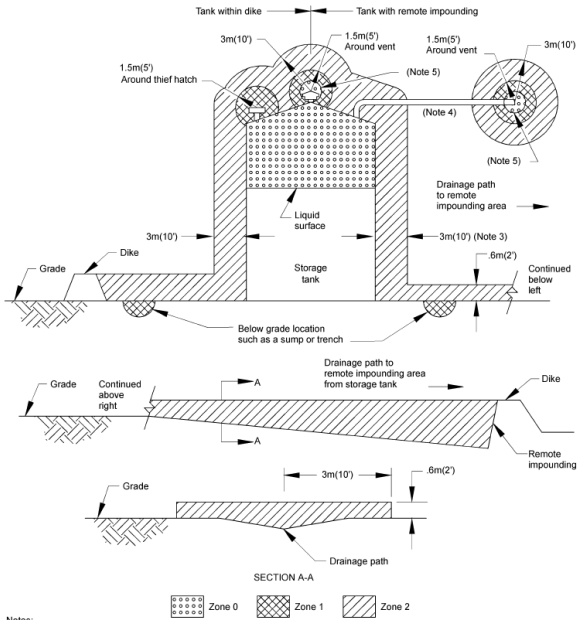
## IE 15:

- For pilot plant and large scale, if adequate ventilation (maintaining maximum 25%LEL) is not guaranteed it is recommended to consider Zone 2 at lowest level minimum.
- Area with non-Ex classified should not be located in the same room as Ex-classified.
- It should be possible to isolate all ignition source, raise alarm without causing an ignition risk.
- Purge box help non-Ex equipment to be operated in hazardous area

SCG CHEMICALS

# Area classification vs. Electrical classification

## Hazardous Area classification




**Zone, hazardous extent, gas group, temp class**

## Electrical classification

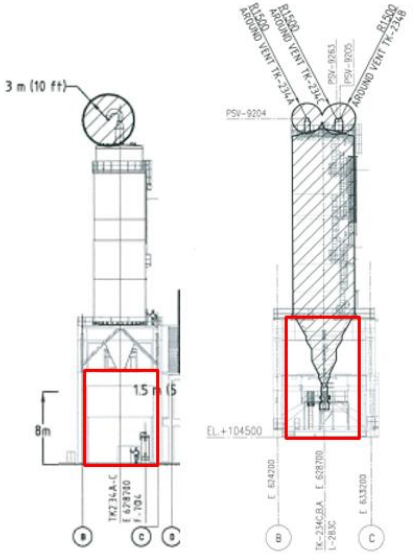
| | |
|---|---|
| ATEX | II 2G Ex ib IIC T4 Gb<br>II 2D Ex ib IIIC T135°C Db IP6X |
| IECEx | Ex ib IIC T4 Gb<br>Ex ib IIIC T135°C Db IP6X |
| NEC500 | Class I, Division 1, Groups A,B,C,D T4<br>Class II & III, Division 1, Groups E,F,G T4 |

**II 2G Ex ib IIC T4 Gb**

- **II** — Other places
- **2G** — Cat.2: Zone 1, 2 Gas
- **Ex** — Global IEC *No Ex symbol on non-electrical equipment
- **ib** — Internal protection method
- **IIC** — Gas Group
- **T4** — Temperature class
- **Gb** — Protection class

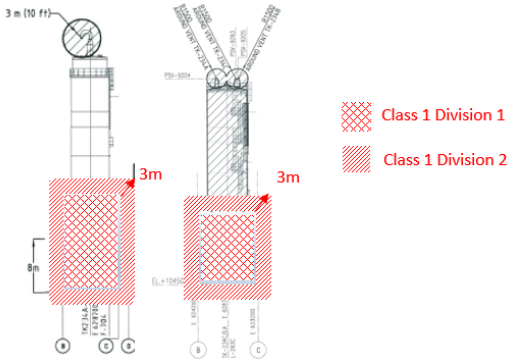
# Case study: Misunderstanding site condition for ventilation evaluation

## HAC drawing of project




Contractor document defined this area as an unclassified area due to adequate ventilation without leak source.

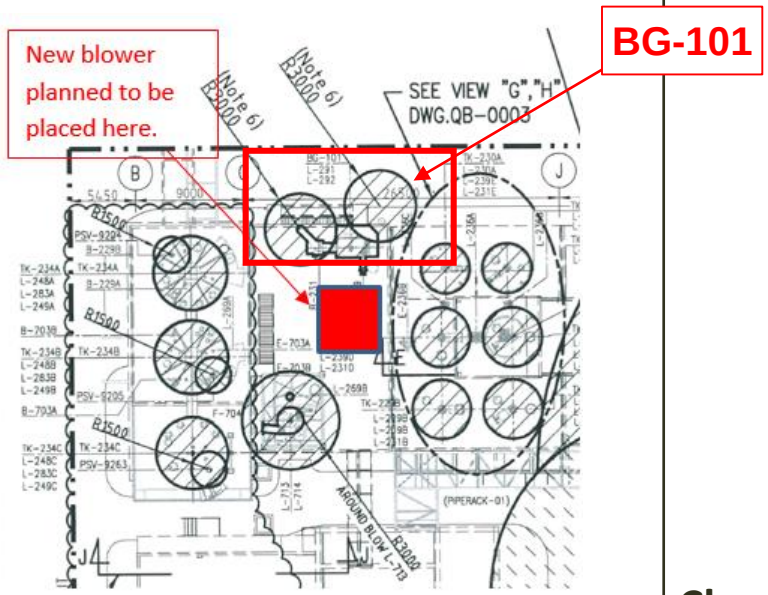
## Actual site condition


Inadequate ventilation due to enclosed area shall be classified as Class 1 Division 1 due to leak sources at flanged connections at bottom of silo.

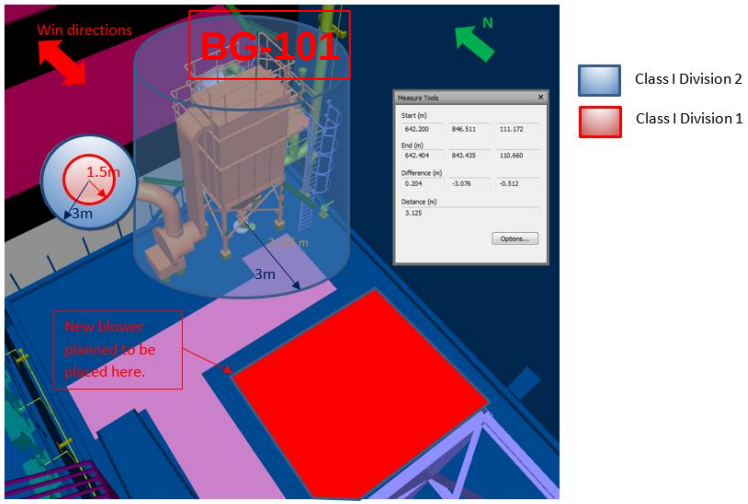
# Case study: Misunderstanding source of release and Install new equipment near hazardous boundary

## HAC drawing of project




Project does not consider continuous release (Division 1) and flange leak source (Division 2).

## Revise Hazardous Area

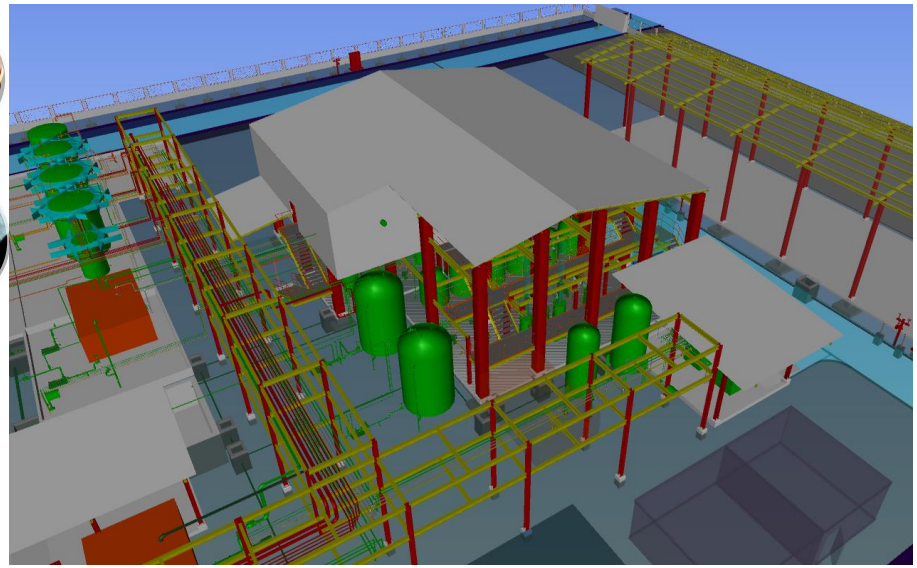



**Class I Division 1**: Flammable gas exist under normal operating conditions-> Continuous vent

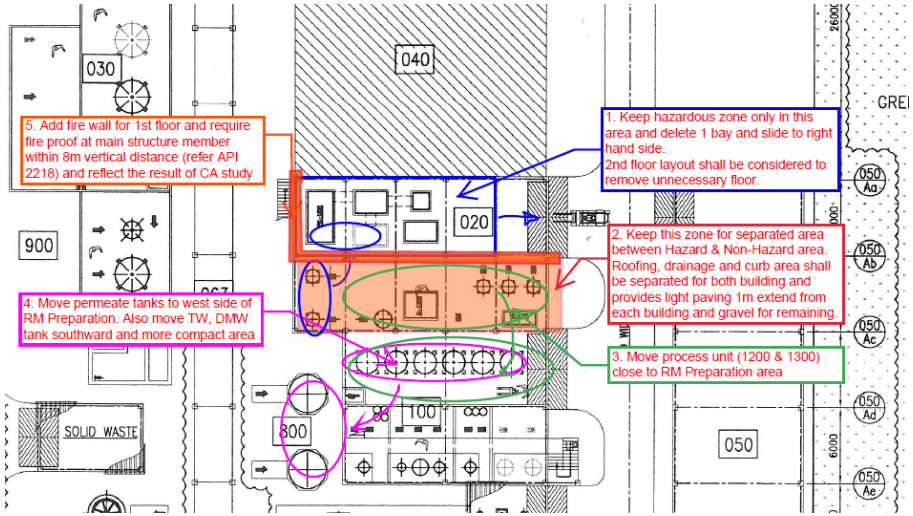
**Class I Division 2**: Gases normally will be confined within or closed systems from which they can escape only in case of accidental rupture or breakdown -> Flange

SCG CHEMICALS

# Case study: Layout vs. hazardous area



**Original**: No separation of hazardous area




**Revise version**: Separation of hazardous area by safety distance or vapor tight wall save:

- Electrical classification
- Fire proof structure
- Fire protection
- Detection system
- Handling and HSE plan

SCG CHEMICALS

# Thank you for your attention