EAZe Process for Hazardous Area Classification of a Multipurpose Chemical Plant

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Abstract- Multipurpose chemical plants are by nature required to swiftly switch between the manufacturing processes and products. Although the buildings and equipment used in the manufacturing process remain largely the same, the chemicals used can vary greatly. Based on this rate of change, a system is needed to enable rapid evaluation of new chemicals and properly document the reviews and process safety records. Without an efficient engineering review system for these rapid changes, ensuring the safety of personnel, assets and the community at large can be at risk.

In a typical multipurpose chemical plant, there are multiple sources of releases that can create hazardous atmospheres. Each scenario requires a specific hazard assessment to determine the type of hazardous zone and the extents of it. This issue can be further compounded if the plant operations are constantly modified to introduce a process to manufacture a new chemical or reintroduce a process that was used previously.

Each time a plant undergoes a change either by NPI (new product introduction) or by modifications via MoC (management of change) the hazardous area classification assessment needs to be revalidated. This is a complex exercise considering the number of scenarios and the number of chemicals that need to be assessed to ensure that the area is zoned appropriately.

It may be prudent to identify a solvent basis as a means to quickly determine the zone extents for explosive gas atmospheres.

Based on the point of source methodology the author presents a simplified way to determine the base solvent for the area classification for a multipurpose chemical plant. Using the guidelines within the standard 60079-10-1 & 2 and extensive experience, PSK Pharma was able to craft an **EAZe** process for this complex problem. **E**xplosive **A**tmosphere **Z**oning **e**xtents (**EAZe)** process lays out the steps necessary to effectively carry out a hazardous area classification and has come up with a novel methodology for reducing the efforts necessary by establishing a process to rank the chemicals based on their physical properties. The majority of the zoning is based on one of the three scenarios identified below. Currently there are three factors that are identified each one for a release mechanical based on the scenarios as follows to identify a base solvent that provides the maximum zone extent.

a) Release of vapours due to displacement of vapours e.g., drum filling, solids charging, etc.
b) Evaporation of pool of flammable material which has lost containment, e.g., loss of containment of drum of flammable liquid.
c) Release of liquid/gas under pressure due to damage/rupture of seal, e.g., flange seal leak from a pump at discharge end.

During the assessment of various scenarios for various chemicals using HAZCALC software, it was found that the higher the value of the factor, meant larger zone. Thus, for a multipurpose chemical plant, this ranking process will assist in reducing its efforts on revalidation by establishing a 'base chemical' for the assessment.

Another key area for consideration is the zoning of explosive dust atmospheres. Although there are regulatory standards in place which offer some guidance on explosive dust atmospheres, the guidance is not exhaustive, and the assessors use engineering judgement based on the available information to classify the zones. Depending on safety policies in place at the company and/or the biases of the evaluator, it is common to err on the side of caution and significantly overestimate the zone extent to be conservative. This conservatism can lead to additional cost and schedule impact for conversion projects.

This paper presents some key challenges on the subject. These processes have been developed while working on and leading numerous hazard evaluation projects in industry. This methodology has been shown to improve the effectiveness of the Hazardous area classification process for a multipurpose chemical plant.

Keywords- Multipurpose Chemical Plant, CDMO, Hazardous Area Classification, BS EN 60079-10-1, EI 15, BS EN 60079-10-2, HAZCALC, flammable substance, DSEAR, **EAZe** (Explosive Atmosphere Zoning extents), LEAC (List of Equipment for Area Classification) Pool Evaporation, Fire, Dust Explosion

1. Introduction

The pharmaceutical industry is experiencing a huge demand for specialized therapeutics in preparedness for pandemics. Vaccine development and deployment to contain Covid-19 was effective because some of the multipurpose chemical plants were able to take the load off the big dedicated pharmaceutical companies. Working relentlessly, these facilities were able to produce the vaccines to meet the global demand.

Multipurpose chemical plants can vary in size and complexity. For decades, they have been bringing complex molecules to market providing a valuable service to the global healthcare infrastructure. The majority of the multipurpose plants can work on 40+ molecules at any given time, depending on the market demand.

Multipurpose chemical plants have the need to receive, test, store and handle, raw materials, intermediates, and finished products daily. Many of these chemicals can be classified as flammable or similarly hazardous. Thus, the multipurpose chemical plants must comply with the DSEAR regulations which are concerned with protection against risks from fire and explosion.

Lack of understanding of the nature of materials being handled or handling flammables in an environment that is not appropriately rated can lead to dangerous situations causing fatalities, asset damage and more importantly delays in the vital medicinal products being available to the patients.

Due to inherent flexibility, the multipurpose plants need to be reassessed and revalidated for safe systems of work to be in place prior to a new product being manufactured; an old product reintroduced; or modified unit operations for a previously manufactured product. There may be other reasons a facility will need to review their basis of safety and explosive atmosphere zoning extents viz., the regulatory changes, changes in guidelines, changes in ownership or if the facility is a contract manufacturing site, the client's and operators' processes/practices may not be aligned.

It is extremely challenging for designers, operators, and safety practitioners to accurately determine the explosive atmosphere zoning extents due to the inherent variability in the process. For facilities engaged in specialty/protected molecules this is even more challenging due to the lack of information on material properties / data. Thus, most contract manufacturers maintain an in-house hazard evaluation facility to combat this issue.

Compliance risk is another challenge the facilities must overcome to maintain the safety of assets and people. Although the regulations have been in place for over two decades, most facilities have an understanding that the output from a hazardous area classification exercise is limited to a drawing showing zone types and extents. Most assessments lack associated documentation to fully justify the selection of certain zones and the reasoning behind the selection.

Hence, the aim of this paper is to define the challenges that a multipurpose chemical plant faces when it comes to assigning zone extents to explosive atmospheres. Then propose an easy and robust process for accurately estimating the extents of hazardous atmospheres and properly maintaining documentation of decisions and actions. The process is developed largely based on the guidelines in BS EN 60079-10-1 & 2 and assumes a good working knowledge of these standards.

2. Challenges in Determining Explosive Atmosphere Zoning extents (EAZe)

2.1. Information Required

A large amount of detailed information is required to determine the explosive atmosphere zone types and extents. If it is an existing facility and the required information is not readily available, then the generation and maintenance of this information is a significant task. The key information required for determining the type and extent of a hazardous zone requires collection of information from process outlines, descriptions, equipment specification, heat/mass balance, P&IDs, layout drawings, pipework arrangement (isometric drawings), electrical equipment layouts, radio frequency devices layout, vent register and relief device data sheets. In most facilities this information is scattered among different disciplines, and there are different owners managing the systems where this information is stored or recorded. Once the zoning exercise is complete it is necessary to keep the data relevant for the current process. It is important for the facility to bring in awareness among various users of the zoning extent data on its applicability. The following infographic in Figure 1 provides an example of various applications of HAC alongside the information contained in HAC to assist the safety reviews during various stages of the plant design, safety review, operation, and maintenance.

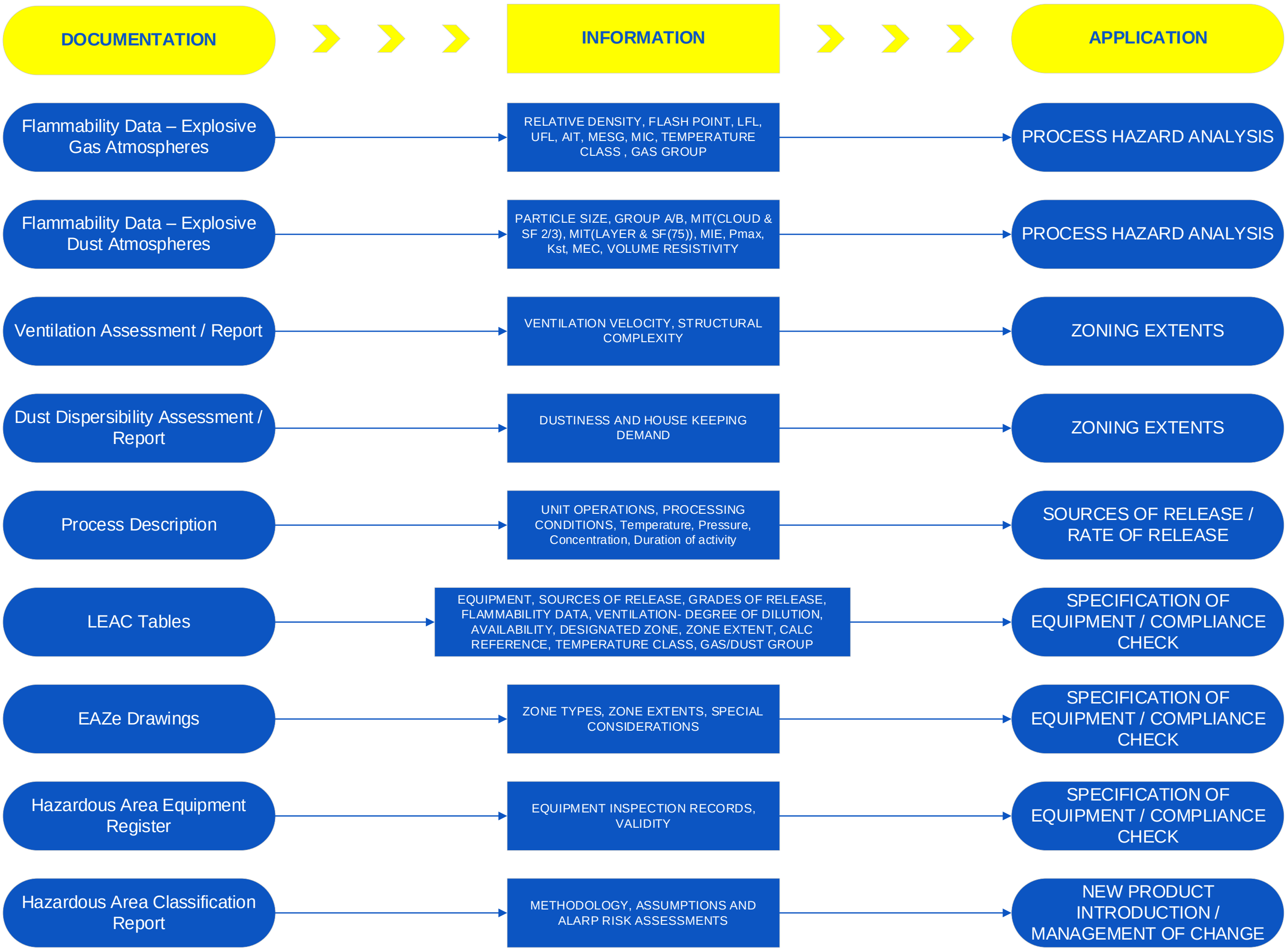

Figure 1: A Link between HAC Documentation and their Application

2.2. Lack of Proper Guidelines

The standards supply different approaches to decide the zoning extents, i.e., direct examples, point of release and risk-based approach. The guidance documents elaborate on some of the most common operations and the zone extents associated with those scenarios. However, finding a direct example to adopt is not always easy. Thus, there is a need to use engineering judgement to estimate the zone extents based on the examples in the standard. As an example, the standards on dust zoning lack a definition on zones with negligible extent and thus the assessment could be erroneous, if the zoning in the standard is applied without quantifying the risk.

The guidelines within standard 60079-10-1 when it comes to documenting the type of zone are misaligned. The following table and the guidelines for showing zones on plan and elevation drawing do not seem to align. There are 9 different types of zones across 21 categories; however, the drawing designation is only shown for 3 zone types.

Grade of release	Effectiveness of Ventilation						
	High Dilution			Medium Dilution			Low Dilution
	Availability of ventilation						
	Good	Fair	Poor	Good	Fair	Poor	Good, fair or poor
Continuous	Non-hazardous (Zone 0 NE)[a]	Zone 2 (Zone 0 NE)[a]	Zone 1 (Zone 0 NE)[a]	Zone 0	Zone 0 + Zone 2	Zone 0 + Zone 1	Zone 0
Primary	Non-hazardous (Zone 1 NE)[a]	Zone 2 (Zone 1 NE)[a]	Zone 2 (Zone 1 NE)[a]	Zone 1	Zone 1 + Zone 2	Zone 1 + Zone 2	Zone 1 or zone 0[c]
Secondary[b]	Non-hazardous (Zone 2 NE)[a]	Non-hazardous (Zone 2 NE)[a]	Zone 2	Zone 2	Zone 2	Zone 2	Zone 1 and even Zone 0[c]

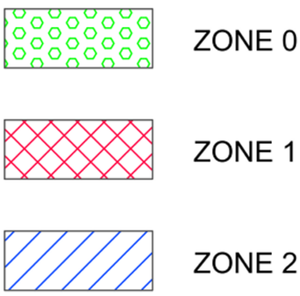

Figure 2: Misaligned Guidance (Excerpts from 60079-10-1)

The author understands that the standard is a guideline, and it should not be too prescriptive. However, lack of standard ways of working for marking up the zone types when it comes to documenting hazardous zones are leading the users to adopt innovative methods thus driving inconsistent approaches.

2.3. Too Many Parallel Processes

By its very nature, the multipurpose chemical plant needs to be able to swiftly switch between the manufacturing processes and chemicals. However, the business operating processes that are used in the facility are not always aligned. The diverse groups or disciplines who are custodians of varied information may be working with different sets of data or are under time pressure to complete the task without proper documentation. This is mostly clear in case of subcontracted work. Poor management of subcontractors may lead to lack of current and relevant data to enable correct assessment of sources of release and ultimately the extents of explosive atmospheres. The management of change process which should overarch all the other process might categorise the document update as low category action thus leading to a gap in the information set.

2.4. Reviews are Not Conducted Timely Manner

Another major challenge is the lack of feedback in a timely manner. If assessments are not carried out prior to release of (incorrect specification of equipment) approved for construction drawings, it may result in errors or omissions during construction or commissioning. If this recordkeeping activity was subcontracted, then this communication gap between the owners and the contractors might lead to rework and loss of valuable time. The emissions calculations that are approximated at feed stage might not be reviewed again at the detailed engineering stage thus leading to incorrect information carried forward in the project.

2.5. Documentation is Not Relevant and Current

Due to market pressures to meet the project timescales, often the documentation does not get properly prioritised and resourced. Hence, despite the diligence of a hazardous area classification exercise, it has been observed that many reviews are not properly documented. Common omissions included inadequate documentation of Gas groups, temperature classes on the HAC report or complete drawings sets. In most of the cases, the HAC documentation starts and stops at HAC drawing showing the zone extents but without any explanation or justification of the assessment. If this incomplete documentation is used as a basis for management of change or assessing the process hazards while conducting a PHA, the result can be inaccurate and potentially dangerous. Thus, it is necessary to use complete HAC documentation i.e., drawings and report which detail all the assumptions and justification for zone types and extents.

The challenges and the issues leading to incorrect assessments can be summariesd in an infographic as shown in Figure 3.

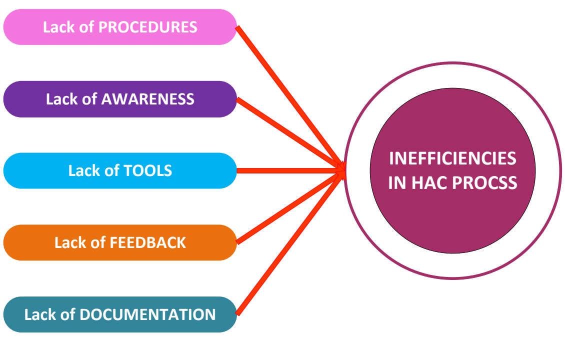

Figure 3: Factors leading to incorrect Area Classification

Whether it is either lack of proper procedures or lack of awareness or lack of appropriate tools for assessment or lack of communication between the stakeholders or lack of documentation or all the above, the area classification will be incorrect. To overcome the issues using the guidelines in the standard 60079-10-1 and based on the experience in the field PSK Pharma has come up with an easy-to-follow procedure to ensure assessments take into account all the necessary information and is systematically recorded using Explosive Atmosphere Zoning extents (**EAZe**) process.

3. Classification Methodology for Explosive Gas Atmospheres

Multipurpose chemical plants have a need to use flammable liquids above their flash points on various operations. Handling of these materials from receipt, transfer, storage, and processing carry the risk of forming flammable gas atmospheres. Thus, it is necessary to manage the risks posed by the various scenarios during handling of these liquids/vapours. The following five step process has been carefully crafted based on years of experience and the guidelines with BS EN 60079-10-1 and IE15 for classification of areas containing Liquids, Vapours and Gases. This process will be referred to as **EAZe** (Explosive Atmosphere Zoning extent) Process for multipurpose chemical plants.

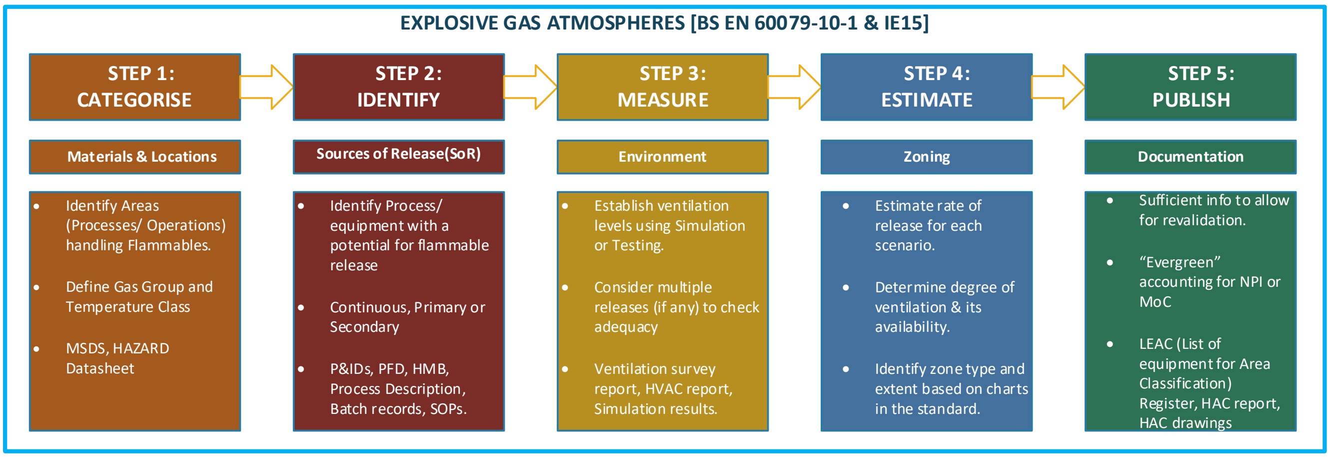

Figure 4: EAZe Process for Explosive Gas Atmospheres

3.1. Step 1: Categorisation of Areas

The purpose of this step is to categorise the plant area being subjected to hazardous area classification as an area where there are or there could be explosive atmospheres due to flammable liquids, vapours, or gases. The areas that do not pose a risk are classified as non-hazardous.

To understand the extent of risk, the materials being handled need to be assessed for flammability using the Supplier Hazard datasheet and/or Material safety datasheet (MSDS). Based on the flammability data, the area can be assigned with a gas group and a temperature class.

At the end of this step, the assessor should have categorised the plant areas into hazardous and non-hazardous areas and listed all chemicals handled along with their flammability data.

3.2. Step 2: Identification of sources of release and grades of release

The purpose of this step is to assess the actual plant conditions, to identify sources of release for each plant equipment/item and/or unit operation. The necessary information for understanding the plant conditions and identification of sources of release should be based on the discussion with operations, engineering, maintenance, and safety groups. Their operational experience combined with review/assessment of the design/operational documentation (Process Flow Diagrams, Heat and Mass Balance, Process & Instrumentation diagrams, equipment specifications and operational modes, process outlines, batch record sheets and standard operating procedures) should allow each source of release to be classified as a Continuous, Primary or Secondary grade of release.

At the end of this step the assessor should have developed a List of Equipment for Area Classification (LEAC) with all the equipment and the associated sources of release identified.

3.3. Step 3: Measurement of ventilation

The purpose of this step is to assess the plant to understand the ventilation conditions. A quantitative ventilation assessment can be performed to capture air velocities in the area under consideration for the assessment. Ventilation shall be adequate to prevent the accumulation of flammable concentrations of materials in air. This is normally achieved by keeping the air velocity to above 0.5m/s and avoiding any stagnant zones near the sources of release. However, this may vary based on the scenario being assessed.

Inadequate ventilation can be a result of simultaneous release from more than one source. Thus, it is necessary to take into consideration cumulative release rates for establishing the safe ventilation rates for an area when multiple release sources were encountered in a particular area of operation, e.g., the reactor bay.

At the end of this step the assessor should have a table of ventilation velocity assigned to each area / source of release.

3.4. Step 4: Estimation of Extent of Explosive Atmospheres

The purpose of this step is to determine the extent of explosive atmosphere from the source of release. The two main inputs to this assessment are the release rate and the influence of ventilation. A calculation along with the charts in BS EN 60079-10-1 should be used to determine the hazardous area zone extents using point of release method.

Ventilation rate if found inadequate (as measure in Step 3) based on the degree of dilution; engineering solutions shall be considered to improve the ventilation in the area or reduction of vapour generation.

Further, where the release rates can't be established for a source of release a risk-based approach can be used to determine release rate. This approach should only be used for a secondary grade of release. It is always advisable to carry out a dispersion modelling to establish the extent of release for a primary or continuous grade of release.

At the end of this step the assessor should be able to populate the LEAC table with all the necessary information to allow the HAC document pack to be prepared.

3.5. Step 5: Documenting the findings

The purpose of this step is to document sufficient information to allow a basis for future (re)validation of the HAC for the area for new product introduction (NPI) or modifications to the current process via a management of change (MoC). As a minimum there should be a HAC report detailing the assumptions and justification for selection of zone types and zone extents, LEAC table and drawing showing the extents in plan and elevation.

4. Challenges for Explosive Gas Atmospheres

4.1. Base Solvent for the Assessment

Multi-purpose plants use various solvents during the manufacturing of chemicals / active pharmaceutical ingredients. Due to the fast-changing process and chemicals deployed for manufacturing, a definitive area classification is impossible to determine and maintain on an ongoing basis. Thus, in order to perform the HAC assessment, it is necessary to have a representative solvent to be used as a basis. To determine the base solvent for the assessment it is necessary to understand the factors influencing the release rates under various release mechanisms. Explosive gas atmospheres formed under following three release mechanisms were used for further assessment to identify a quicker method to rank the chemicals for each mechanism.

- Release of vapours due to displacement of vapours e.g., drum filling, solids charging, etc.
- Evaporation of pool of flammable material which has lost containment, e.g., loss of containment of drum of flammable liquid.
- Release of liquid/gas under pressure due to damage/rupture of seal, e.g., flange seal leak from a pump at discharge end.

4.1.1. Vapour Pressure

The zone extent for a variety of solvent was determined using HAZCALC software. These assessments revealed that the zone extents can be expressed as,

$$\text{Zone extent} = a\,(F1)^{b}$$

where F1 is the Vapour Pressure Factor and a, b are constants.

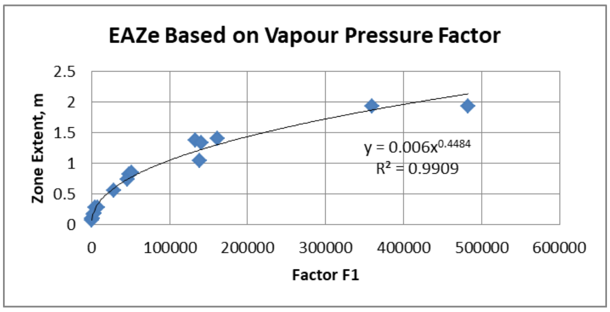

Figure 5: EAZe Process – Vapour Pressure Factor

The factor F1 is found to be a function of vapour pressure, LEL, vapour density and molecular weight of the flammable liquid.

4.1.2. Pool Evaporation

Another exercise was conducted to determine the representative solvents for the assessment of pool evaporation. The pool factor F2 also correlates with zone extent by power law as follows:

Zone extent = a (F2) b where a, b are constants.

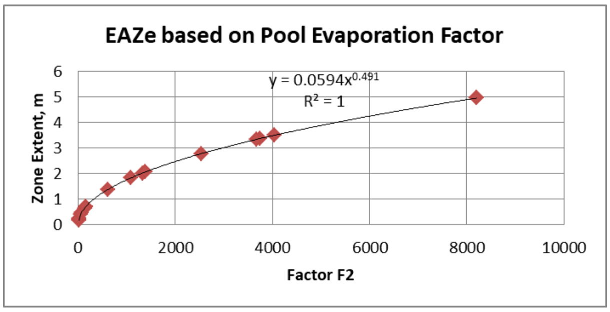

Figure 6: EAZe Process – Pool Evaporation Factor

The factor F2 is found to be a function of vapour pressure, LEL, and molar mass of the flammable liquid.

4.1.3. Pressurised Liquid Release

Similar exercise was conducted to determine the representative solvents for the assessment of pressurised liquid release. The pressurised liquid release factor F3 also correlates with zone extent by power law as follows:

Zone extent = a $(F3)^b$ where a, b are constants.

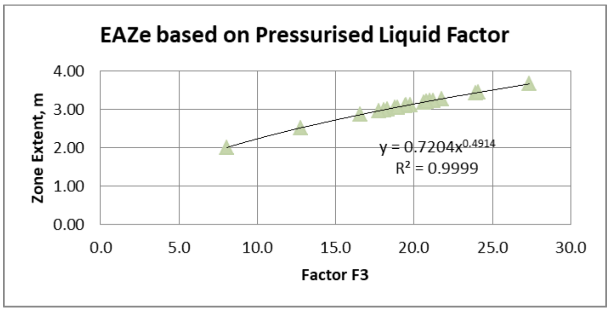

Figure 7: EAZe Process – Pressurised Liquid Factor

The factor F3 is found to be a function of LEL, vapour density, and liquid density of the flammable liquid.

The simulation exercise led to recognition of three factors each based on the mode of release. For each chemical under consideration higher value of these factor meant larger extent. Thus, the factor(s) based on the properties of the chemical will be useful to rank the chemicals for that scenario and avoid the need for repetitive calculation for each chemical. The correlation obtained in each case are as presented in sections above.

Establishing these factors for the range of raw materials/products processed in a bay and ranking them based on zone extent will be a useful exercise for a multipurpose chemical plant. This step will assist the multipurpose plants to establish a zone type and zone extent based on the worst-case scenario i.e., area classification carried out based on a 'base chemical' thus future proofing the plant for various set of chemicals and reducing the burden of revisiting the entire process to review and update the documentation.

However, any new chemical that plant plans to introduce into the manufacturing bay will only need to be compared against the base chemical chosen for that area the reducing the effort and time required to validate the hazardous area documentation.

5. Classification Methodology for Explosive Dust Atmospheres

Like flammable liquids the multipurpose chemical plants will invariably handle combustible dusts in its manufacturing process. Whether it is during the dispensing, charging raw materials or collecting product from processing equipment like filters, dryers there is a risk of potential explosive dust atmospheres. Thus, the **EAZe** process for flammable liquids can be slightly modified based on the guidelines with BS EN 60079-10-2 for classification of explosive dust atmospheres. As the steps are effectively the same, the process name is retained as **EAZe** (Explosive Atmosphere Zoning extent) Process for multipurpose chemical plants.

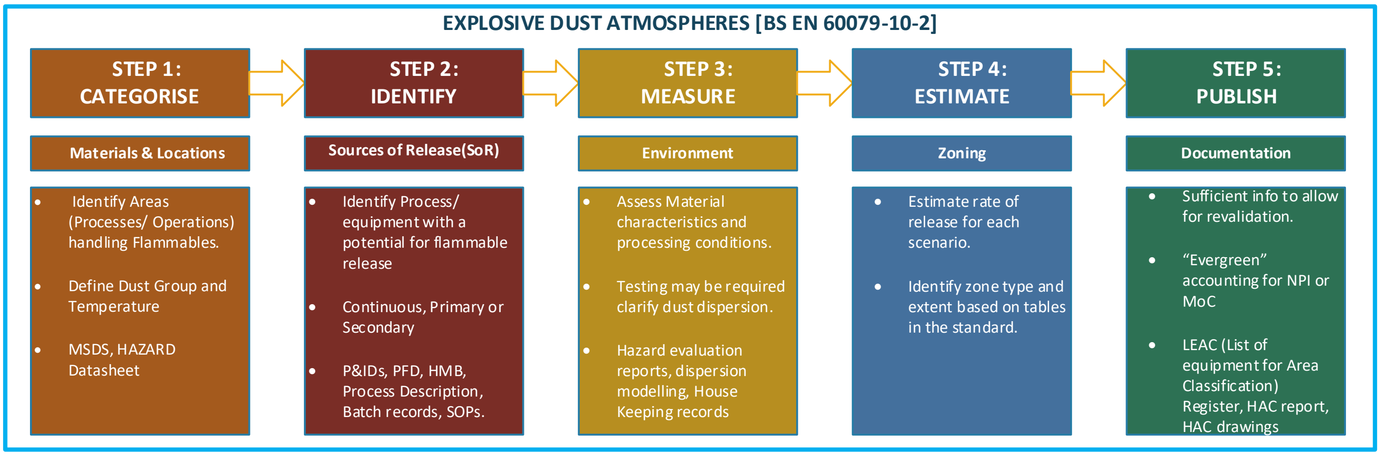

Figure 8: EAZe Process – Explosive Dust Atmospheres

5.1. Step 1: Categorisation of Areas

The purpose of this step is to categorise the plant area being subjected to hazardous area classification as an area where there are or there could be combustible dust clouds and/or dust layers. The areas that do not pose a risk are classified as non-hazardous.

To understand the extent of risk, the materials being handled need to be assessed for explosion hazard using the Hazard datasheet and/or Material safety datasheet (MSDS). Based on the material data, the area can be assigned with a dust group and a temperature rating for allowing equipment selection. If the powder/solid does not have material properties assessed and/or documented, it may be safe to assume that the material has an extremely high sensitivity for dust cloud ignition (i.e., MIE <4mJ) for the purpose of the assessment.

At the end of this step, the assessor should have categorised the plant areas into hazardous and non-hazardous areas and listed all chemicals handled along with their flammability data.

5.2. Step 2: Identification of Sources of Release and Grades of Release

The purpose of this step is to assess the actual plant conditions to identify sources of release for each plant equipment and/or unit operation. The necessary information for understanding the plant conditions and identification of sources of release should be based on the discussion with operational, engineering, maintenance, and safety authorities. Their operational experience combined with review/assessment of the design/operational documentation (Process Flow Diagrams, Heat and Mass Balance, Process & Instrumentation diagrams, equipment specifications and operational modes, process outlines, batch record sheets and standard operating procedures) should allow each source of release to be classified as a Continuous, Primary or Secondary grade of release.

This step is used to record the possibility of the formation of dust layers that may be disturbed to form explosive atmospheres and the nature of the house keeping arrangements that are currently deployed or needed in the plant areas.

5.3. Step 3: Probability of dusty atmosphere

The purpose of this step is to determine the likelihood of the dust being released into the atmosphere and further the likelihood of presence of explosive dust atmospheres in that plant area. This should be recorded in the dust hazard assessment sheet and along with pictorial evidence of the level of dust layers within an existing plant, if the assessor is revalidating the zone extents.

5.4. Step 4: Estimation of Extent of Explosive Atmospheres

The purpose of this step is to determine the extent of explosive atmosphere from the source of release. Depending on the circumstances, not every release will form an explosive dust atmosphere. To form an explosive dust atmosphere, the combustible dust must have been dispersed in concentrations in the explosion range. A decision on the zone type and extent of zones should be recorded in the dust assessment sheet based on quantity of chemical handled. Data on dispersion of dust may not be readily available. Typical dispersion rates and spillage rates from reputed references can be found within published data or can be developed with laboratory assessments. Further, the house keeping standards that are observed in the plant will provide useful information in estimating the zone extents.

5.5. Step 5: Documenting the findings

The purpose of this step is to document sufficient information to allow a basis for future (re)validation of the HAC for the area for new product introduction (NPI) or modifications to the current process via management of change (MoC).

6. Challenges for Explosive Dust Atmospheres

The two key challenges in estimating the zone extents apart from the general challenges described in section 2 are as listed below:

6.1. Material/Material Data

In chemical/pharmaceutical industry dusts can exist in many unit operations within the plant. Not all dusts are combustible in nature, however most organic molecules can form explosive clouds. Thus, there is a need to understand whether the dust is combustible by carrying out appropriate hazard analysis / testing. Most often these tests can be expensive and not all the operating plants are equipped with hazard laboratories to carry out the testing in house. However, that should not be the factor for not documenting the material properties in the hazard assessment. The material supplier for raw materials will have the data and it should be included in the material safety datasheet, if not, testing in a reputed hazard evaluation laboratory should be conducted to note the hazard parameters for the dust, viz., minimum ignition energy, minimum ignition temperature of the dust cloud and layer, minimum explosive concentration.

6.2. Competence of the Assessor

Historically, electrical ignition sources have been a key area of the HAC assessment. However, as the process of HAC has evolved, the factors contributing to dust explosion is more widely understood. Dust explosion will only occur when all the five elements of dust explosion pentagon are present. Dust explosion pentagon is an expansion of the fire triangle with elements like, dust (fuel), ignition, oxidant (e.g., oxygen) and two more additional elements in the form of dispersion of dust cloud at a minimum explosive concentration and is confined in a closed space. For the assessment to be effective, an understanding of the design conditions and process upsets/hazards expected during normal operation is necessary. As lack of understanding of the above might result in the zone extents being under or over estimated. Thus, the assessor shall have process knowledge or training to fill the gap. To make the process smoother for classifying Hazardous Dust zones, always ponder on the following questions, prior to starting the assessment.

1. Have the combustible dust properties and process conditions available and recorded in the pre-requisite data?
2. Has the assessor understood the process, process conditions and the area conditions, fully?
3. Is there a specific example available within the standards that can be applied directly to a scenario?
4. Is the HAC documentation for the plant being modified, kept up to date?
5. If the assessment is for a new plant, does the documentation fully list the equipment for classification and describes the scenario for assessment well.

7. Discussion

Hazardous Area Classification requires a thorough understanding of the operational steps, process conditions and the knowledge of associated equipment. The flammability data for the process/materials being assessed shall be compiled based on the published information or established via laboratory tests prior to starting the assessment. The **EAZe** process focuses on following four elements to ensure the effectiveness of zoning explosive atmospheres.

The processes used at the site shall be aligned so that business operating procedures are able to recognize the need for reviewing and updating the zoning information. This shall be carried out very early in the design process whether it is for a new product introduction or for change / reintroduction of an existing process. The other aspect generally overlooked is the subcontractor engagement. There shall be a check step in a process to ensure the practices and procedures carried out by the subcontractor are not negatively impacting the overall process at site.

The workgroup responsible for the assessment should always have a process owner who oversees the entire process. This is crucial as the competent person responsible reviews the information, ensures it is up to right standards and the assessments are carried out in a consistent and standard format. The assessor shall consult subject matter experts as necessary to gain full understanding of the process prior to taking up the assessment. The guidance in the standards may be intentionally vague to allow the assessors to evaluate the scenarios thoroughly prior to making decisions on zone extents. This person shall be the linkage between various process owners and disciplines so that all the changes taking place on the site are communicated well, documented and assessments are revalidated as necessary.

Traditionally there have been various tools used for carrying out the zoning exercise. The most widely used being an in-house generated MS EXCEL spreadsheet. There is other dedicated software like Quadvent by HSL, HAZCALC by POL-Safety, EXHAC by Engworks assisting facilities to zone the explosive gas atmospheres. The tool chosen by site shall be validated to ensure that the tools are kept up to date. The outputs from these packages shall be controlled and managed very well to ensure there are no multiple copies of the same assessment or the assessment is not readily available to the entire workgroup.

The final step in the process is to ensure that the assessment process feeds back to the design process, equipment selection and procurement, installation process, installation verification process and standard operating business process on a regular basis. This feedback process is vital to ensure that efficacy of the other elements discussed above. It will also assist with fine tuning the steps within the assessment process to reap maximum benefit from the **EAZe** process.

The documentation relating to assessment of explosive atmospheres is critical to demonstrate that the equipment within the area is fit to operate and it should be documented well, describing the scenarios considered for the assessment. Keeping the documents up to date should not be seen as laborious and expensive process. Failing to keep documentation evergreen might throw challenges whilst considering a revalidation of the assessment on the back of a plant change or introduction of new process within that plant area.

Based on the above discussion, author would like to revisit the Figure 3 which summarized the inefficiencies in the process of area classification. Thus, for an efficient process for classification of explosive atmospheres, aligned procedures, competent team/team members, fit for purpose tools, robust review process and evergreen documents are necessary. The elements of an efficient process for area classification are depicted in Figure 9.

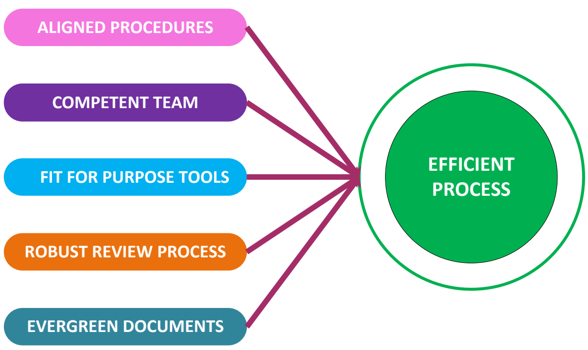

Figure 9: Elements of an Efficient Process

8. Conclusion

As described in this paper, **EAZe** process for determining the extent of zones for a complex multipurpose chemical plant is comprehensive and robust. The author is of the belief that **EAZe** process will shift the thinking from just producing a set of hazardous area drawings to a more systematic identification of hazardous areas and recording of scenarios/assessments to assist compliance with regulations and more importantly to keep the plant, people, and community safe.

EAZe process has come up with a novel method to compare the risk of flammable liquids, vapours, gases, allowing the ranking of those chemicals for three scenarios. This is very useful for a multipurpose chemical plant which must deal with several chemicals on a regular basis. However, the author would like to do further research to ensure that the **EAZe** process factors are tested for few more scenarios / release mechanisms prior to publishing them for consideration by wider community.

9. References

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