Hamburg University of Applied Sciences

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Evaluation of a Standardized Risk Assessment for Explosion Protection at Seeds Sites

Master Thesis

Master Course Process Engineering

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Abstract

SpeedExs is a software tool developed by Bayer to conduct risk assessments for dust explosions and generate Explosion Prevention and Protection Documents (EPPDs) for its seed sites globally. The development of SpeedExs was driven by the need for a standardised method of risk assessment across all seed sites. The main objective of this thesis is to evaluate the practical adaptability of SpeedExs by conducting risk assessments in various seed sites in the Europe Middle East and Asia (EMEA) region. The thesis begins with a brief introduction to risk assessment and various codes for explosion protection. The methodology to collect the data involved visiting different seed sites, performing risk assessment on them using the software, verifying the results generated by the software and providing action items to develop and implement safety measures in site. Throughout the research process, the software was progressively developed to meet the requirements of the thesis. The thesis presents findings and discussions and provides recommendations on how the functionality of this program can be enhanced in the future, with a focus on the practical application of the software in seed sites. An analysis of the effectiveness of the software is performed, based on the findings from the risk assessments conducted in different seed sites. The thesis concludes with recommendations on how the software can be improved to make it more effective and user-friendly for conducting risk assessments for dust explosions. Overall, the thesis demonstrates the importance of consistent risk assessment practices for explosion safety in seed sites and the potential benefits of using software tools like SpeedExs to achieve this goal.

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Abbreviations

EPPD	Explosion Prevention and Production Document
DHA	Dust Hazard Analysis
MOC	Management of Change
RC	Row Crop
EMEA	Europe, the Middle East and Africa
R&D	Research and Development
SSO	Single Sign On
MIT	Minimum Ignition Temperature
MIE	Minimum Ignition Energy
HSE	Health, Safety and Environment
RACI	Responsible, Accountable, Consulted and Informed
LPG	Liquefied Petroleum Gas

1 Introduction

The Industrial Revolution has played a critical role in the development of modern society, transforming economies, and shaping the world we live in today. However, it has also revealed the dark side of industrialization, which includes the loss of life, assets, and damage to the environment and reputation. The Bhopal Gas Tragedy, Deepwater Horizon Oil Spill, and Fukushima-Chernobyl-Three Mile Island Nuclear Disaster are just some of the incidents that have brought the risks of industrialization to the forefront.

As a result, there is now a growing awareness of the need for a responsible and sustainable mindset in the operation and maintenance of businesses and assets. A critical component of this mindset is the mandatory implementation of a safety culture, which involves a systematic approach to identify, prioritize, and manage potential hazards throughout the lifecycle of operations and assets. This approach includes the use of risk assessment methodology to evaluate and analyse potential hazards and their consequences if they were to occur.

Risk assessment is an overall process that includes hazard identification, risk analysis, risk evaluation, and risk control measures. It involves identifying and analysing potential hazards and the likelihood and severity of their consequences [1]. This analysis results in the generation of an Explosion Prevention and Protection Document, which outlines the findings of the assessment, including control measures and recommendations.

The thesis presented here provides a thorough analysis of the software SpeedExs, developed by Bayer for conducting risk assessments in the seed industry. This evaluation includes an examination of the software's features, performance, and effectiveness in generating results. Additionally, the thesis investigates the reliability of the results generated by the software in identifying potential hazards and implementing control measures to mitigate risk in the seed industry. The thesis begins with a Task Description, outlining the scope of the research. This is followed by a Theoretical Background section, which defines various technical terms used throughout the thesis. The subsequent sections provide an overview of various features in SpeedExs application and the methodology used in sites for assessment. The findings are then presented as Results, which are followed by a Discussion and Recommendations. The thesis concludes with a summary of the overall research and an outlook for future work.

1.1 Bayer crop science

Bayer's crop science division includes the Breeding and R&D of seeds from crops and vegetables which are then used by the Production site for mass production. Together, these divisions are known as Seed Sites.

With over 400 seed sites worldwide, the EMEA region (Europe, Middle East and Africa) of Bayer's network has 209 seed sites, as shown in the Figure 1.

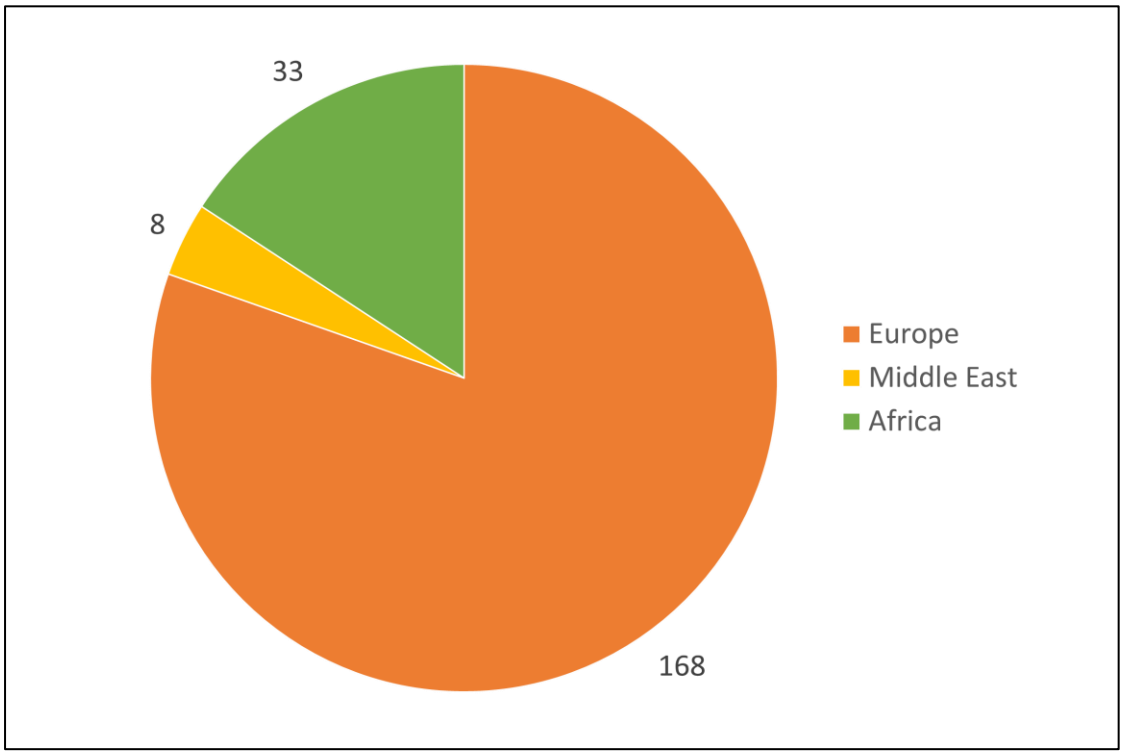


Figure 1: Number of Bayer sites in EMEA region

These Seed sites are categorised into small, medium, and complex based on the number of equipment installations which handle combustible dust or flammable liquids/gases. present at each site. Table 1 shows an estimated count of equipment installations for each of these categories.

Table 1: Seed site classification

S. No	Site Types	Equipment installations handling combustible dust or flammable liquids/gases
1	Small	Less than 50 installations
2	Medium	Greater than 50 but less than 100 installations
3	Complex	Greater than 100 installations

Based on the above categorisation on the number of installations, the Breeding and R&D comes under Small or Medium sites while the Production comes under Complex sites.

1.2 Motivation

During seed processing and extraction at Bayer seed sites, combustible dust and flammable liquids and gases are generated, posing a risk of explosion if ignited in the presence of oxygen.

To manage this risk, Bayer conducts risk assessments and generates Explosion Prevention and Protection Document (EPPD) for each site. However, the methodology and format of these documents vary across sites, causing confusion and nonuniformity. To address this, Bayer collaborated with FORM (WorldAPP, Inc.) to develop SpeedExs, an application for internal auditors to conduct standardized risk assessments and generate EPPDs for seed sites globally.

For my master thesis, I undertook the responsibility of evaluating software by conducting risk assessments of 20 sites out of the 209 Seed sites situated in the EMEA region. During the evaluation, I encountered the challenge of using the SpeedExs application, which lacked a user manual and made me to resort to trial and error to identify the correct use of the sub-fields in the software.

The primary objective of my research was to evaluate and enhance the effectiveness and user-friendliness of the SpeedExs software for risk assessment, while simultaneously identifying its strengths and limitations. Throughout the study, I analysed the usability and efficacy of the software, presenting my findings in Chapters 3, 4, and 5, which encompassed the SpeedExs Application, Methodology for Conducting Risk Assessments in Sites, and Results, respectively.

I obtained the data for my analysis from my experiences using the software across the 20 selected sites. My research seeks to provide recommendations for improving the usability and effectiveness of the software, which could help mitigate challenges faced during risk assessments in the EMEA region.

1.3 Task description

The purpose of this thesis is to accomplish the goals that are outlined in the following sentences

1. The adaptability and practicability of carrying out the risk assessment using SpeedExs software should be evaluated, and results generated by SpeedExs should be verified for its plausibility.
2. Any modifications necessary to make the application more user friendlier should be identified and updated to the development team.
3. This application-based risk assessment approach should be analysed in terms of its strengths and limitations.

2 Theoretical background

This section gives a theoretical background on some of the common terminologies provided by literatures and other sources for understanding this thesis.

2.1 Risk assessment

Risk assessment is a systematic process that involves identifying potential hazards and evaluating the associated risks within a workplace. The goal of this process is to implement reasonable control measures to either remove or reduce the identified risks. The emphasis is on a methodical approach to identifying hazards and mitigating potential risks [2].

The below figure shows elements of risk assessment as stated in EN 1127.

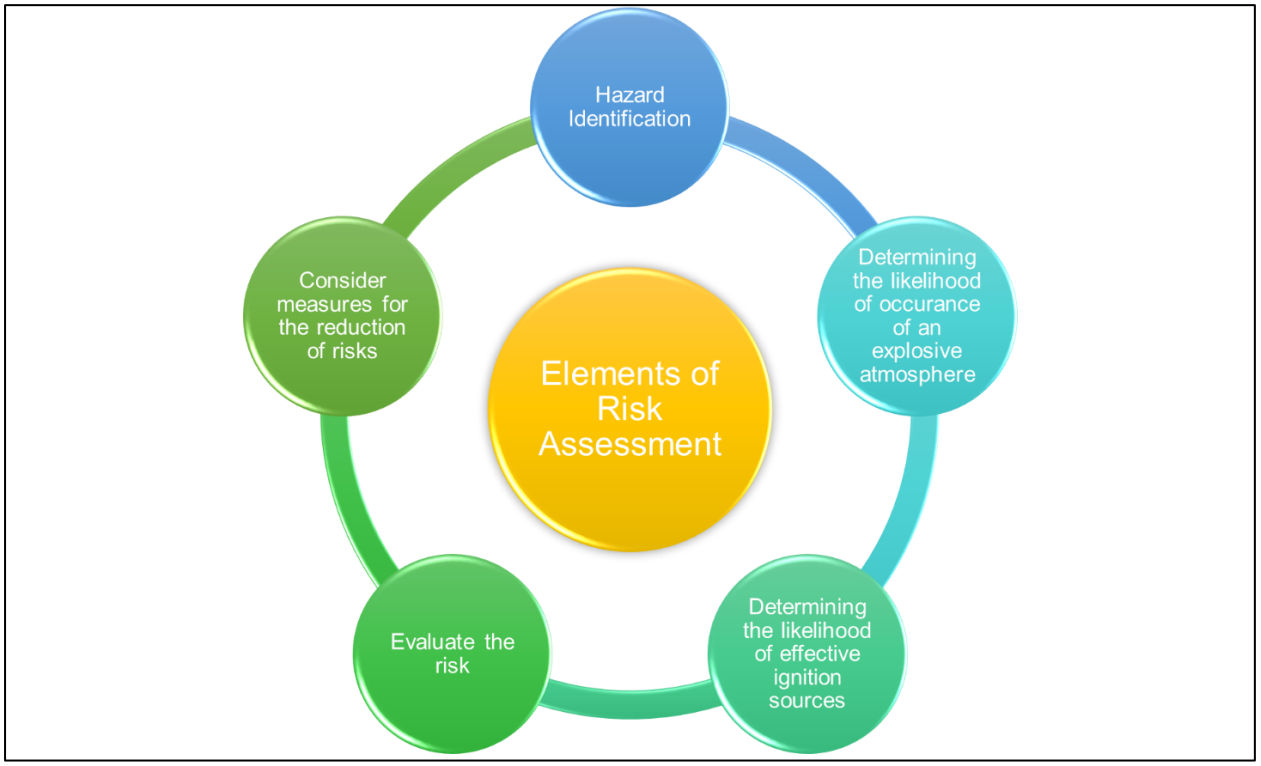


Figure 2: Elements of risk assessment

2.1.1 Explosion hazard identification

The assessment of the explosion hazard cannot rely solely on the presence or absence of ignition sources, as there are other determinants to consider. In order for an explosion to present hazardous effects, four conditions must coincide. These conditions include

- high degree of dispersion of flammable substances,
- the concentration of these substances within their explosion limits in the air,

- the presence of hazardous quantities of an explosive atmosphere, and
- the existence of an effective ignition source. [3]

2.1.2 Safety parameters for hazard identification

EN1127 states that a material's properties can be examined to identify hazards, specifically whether the material has the potential to form an explosive atmosphere when mixed with air [4]. The below table shows the parameters taken into consideration for identifying the hazards. The safety data sheets of flammable gases/liquids and combustible dusts provide information on their properties.

Table 2: Parameters for hazard identification

S. No	Combustion properties	Ignition requirements	Explosion behaviour
1	Flash point	Minimum ignition energy	Maximum explosion pressure (pmax)
2	Explosion limits (LEL, UEL)	Ignition temperature of an explosive atmosphere	Maximum rate of explosion pressure rise ((dp/dt) max)
3	Limiting oxygen concentration (LOC)	Minimum ignition temperature	Maximum experimental safe gap (MESG)

Following are the brief explanation for the above-mentioned terms:

a) **Flash point (For flammable liquids/gases)**: The flash point of a chemical substance is the lowest temperature where enough fluid can evaporate to form a combustible concentration of gas. [5]

b) **Explosion limits**: Explosive limits refer to the concentration range of a substance in air that can potentially burn or explode upon exposure to an ignition source. The lower explosive limit (LEL) and upper explosive limit (UEL) are the two types of explosive limits. Typically, the explosive limits are expressed as the percentage by volume of the substance in the air [6].

c) **Limiting oxygen concentration**: The limiting oxygen concentration (LOC) is the minimum O2 concentration in a mixture of fuel, air, and an inert gas that will propagate flame [7]. Below this concentration, the substance will not burn or explode, even in the presence of an ignition source. The LOC is an important factor to consider when assessing the fire and explosion hazards associated with flammable gases, liquids, and dusts.

d) **Minimum ignition energy**: The Minimum Ignition Energy (MIE) is the lowest energy required to ignite the flammable material in air or oxygen. [8]

e) **Ignition temperature of an explosive atmosphere**: The ignition temperature is the lowest temperature on the surface at which an explosive atmosphere will ignite. [9]

f) **Minimum ignition temperature (For combustible dusts)**: The Minimum Ignition Temperature is the minimum temperature for which a hot surface will ignite a dust cloud. [10]

g) **Maximum explosion pressure (pmax)**: Maximum pressure, the greatest amount of pressure and maximum amount of damage that your dust can cause in a confined space. [11]

h) Maximum rate of explosion pressure rise ((dp/dt) max): The maximum value of the pressure rise, dp/dtmax, per unit time during explosions of all explosive atmospheres in the explosible range of a combustible particulate solid in a close vessel under specified test conditions [12].

i) Maximum experimental safe gap (MESG) (For flammable liquids/gases): The maximum gap of the joint between the two parts of the interior chamber of a test apparatus which, when the internal gas mixture is ignited and under specified conditions, prevents ignition of the internal gas mixture through a 25- mm-long joint, for all concentrations of the tested gas or vapor in air [13].

2.1.3 Zone Classification

Hazardous areas are classified into zones based on an assessment of the frequency of the occurrence and duration of an explosive gas atmosphere, as follows.

- **Zone 0:** An area in which an explosive gas atmosphere is present continuously or for long periods;
- **Zone 1**: An area in which an explosive gas atmosphere is likely to occur in normal operation;
- **Zone 2**: An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time [14].

Dust clouds in the explosive region (above the minimum explosible concentration) are categorised into 3 zones, based upon the grade of release as per EN60079-10-2.

- **Zone 20:** Continuous release inside a dust containment enclosure gives rise to Zone 20 - a place in which an explosive atmosphere, in the form of a cloud of combustible dust in air, is present continuously, or for long periods or frequently for short periods. For example, a mill or pneumatic conveying system.
- **Zone 21:** Primary grade of release gives rise to Zone 21 - a place in which an explosive

atmosphere, in the form of a cloud of combustible dust in air, is likely to occur occasionally in normal operation. For example, bagging points and inspection ports that are frequently opened.

- **Zone 22:** Secondary grade of release gives rise to Zone 22 - a place in which an explosive atmosphere, in the form of a cloud of combustible dust in air, is not likely to occur in normal operation but, if it does occur, will persist for a short period only. For example, leaks from incorrectly fitted lids or spillages [15].

2.2 EPPD

The explosion protection document is the result of an analysis of the explosion risks [16] that outlines the explosion protection measures implemented in a workplace or facility where explosive atmospheres may occur. The EPPD is developed based on a risk assessment of the facility, and it provides detailed information on the potential sources of ignition, the likelihood of an explosion occurring, and the protective measures in place to prevent or mitigate the consequences of an explosion.

2.3 Regulations for dust explosion safety

This section provides an overview of the regulation's provisions relating to dust explosion safety. The software's compliance with these regulations is assessed in the following chapters.

2.3.1 ATEX derivative 1999/92/EC

ATEX 1999/92/EC is a European Union (EU) directive that sets out the minimum health and safety requirements for workers exposed to the risk of explosive atmospheres. It applies to all equipment and protective systems intended for use in potentially explosive atmospheres, as well as the design, manufacture, and placing on the market of such equipment. The directive requires employers to identify areas of their workplace where explosive atmospheres may occur, and to take appropriate measures to prevent or minimize the risk of explosion. This includes the provision of suitable equipment and protective systems, adequate training and instruction for workers, and the implementation of measures to control the sources of ignition. The ATEX directive is intended to protect workers from the risks associated with explosive atmospheres and to ensure that equipment and protective systems are designed and manufactured to meet the necessary safety requirements [17].

2.3.2 EN 1127

EN 1127is a European standard that provides guidance on the safety of work involving flammable gases, liquids, and dusts. The standard covers the identification and assessment of hazardous situations, the selection and application of preventive and protective measures, and the control of

ignition sources. EN 1127 is based on the principles of the European ATEX directives, which aim to ensure the protection of workers from explosion risks in hazardous areas. The standard provides practical guidance to operators and safety professionals on how to manage the risks associated with flammable substances in the workplace. It is often used in conjunction with other safety standards and regulations, such as the ISO/IEC 80079 series on explosive atmospheres. [4].

2.3.3 ISO/IEC 60079-10-2

ISO/IEC 60079-10-2: Classification of areas is a standard related to explosive atmospheres. The standard provides guidance on how to classify areas where explosive dust atmospheres may be present, based on factors such as the likelihood of an explosive dust atmosphere forming and the frequency and duration of its occurrence. The standard also provides information on the various zones that may be present in areas with explosive dust atmospheres, and the types of equipment and protective measures that are appropriate for each zone. Overall, the standard aims to ensure the safe design, installation, and use of equipment in areas where explosive dust atmospheres may be present, in order to minimize the risk of explosions and protect personnel and property [15].

3 SpeedExs Application

SpeedExs developed by FORM (WorldAPP Inc.) for Bayer to be used in its Seed sites is an application-based risk assessment tool. This application offers the flexibility to be used both online and offline, without requiring an internet connection. It is compatible with Windows and macOS operating systems and can be downloaded on a range of desktop and mobile devices, including laptops, smartphones, and tablets.

In this chapter, the terminologies used and the steps involved while using SpeedExs for risk assessment is discussed. This section will be useful to comprehend the information in the subsequent chapters.

3.1 Basic application terminologies

1) **Task:** A Task is a window, which comprises of the Site details like Site address and location, Process/Room and equipment is assigned. Also, where the risk assessment is performed and EPPD report generated. The administrator is responsible for creating and allocating these Tasks.
2) **Pre-defined risk assessment algorithm document:** The document created by Explosion Safety Experts for various equipment relevant to Seed sites serves as the basis for risk assessment in SpeedExs. The equipment data, including the equipment description, equipment configuration, and the algorithm comprising various circumstances that generate hazardous zones and the associated Action item checklist for those zones, is entered into SpeedExs using this document. These evaluated scenarios are fed into the SpeedExs algorithm by admin which forms the risk assessment questionnaire.
3) **Process:** In SpeedExs, a process refers to the activities specific to seed sites. The software includes 10 different process activities that are typically involved in such sites. They help in structuring the plant and the entered equipment in EPPD.
4) **Room:** allows the user to enter a site-specific area, sub-location, or plant area and its information where a group of equipment may be installed.
5) **Pre-defined equipment:** Pre-defined equipment in SpeedExs is an equipment type that has pre-defined background algorithm to which a site-specific equipment of same working philosophy can be assigned. The pre-defined risk assessment algorithm document is used to define a Pre-defined equipment, which is then added into SpeedExs. Each Pre-defined equipment has a set of questionnaires for risk assessment, and the answers to these questionnaires determine the zone of the equipment, ignition source, measures to control

explosion risk and checklist for the respective equipment.

6) **Generic Seed Equipment:** In SpeedExs, Generic Seed Equipment is a type of equipment that requires manual entry of site-specific equipment and its details. The zone classification for this type of equipment also needs to be selected manually, as opposed to Pre-defined Equipment where the algorithm assigns the equipment based on its working philosophy.

7) **Modal window:** On clicking the yellow highlighted icon shown in the below Figure 3, the modal window appears. Before the risk assessment is conducted, equipment-specific details are entered into this designated window. The Figure 10 shows the screenshot of modal window.

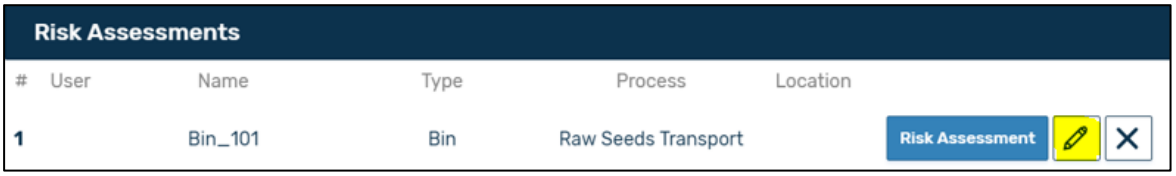


Figure 3: Screenshot of icon to access modal window SpeedExs [18]

8) **Sub-form:** A window that opens up after clicking the below Risk Assessment button highlighted in yellow and contains the risk assessment questionnaires is shown in the below Figure 4. The sub-form window showing risk assessment questionnaire is shown in the Figure 11.

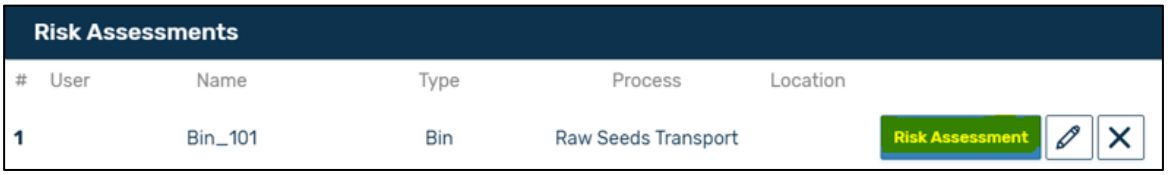


Figure 4: Screenshot of sub-form window button in SpeedExs [18]

9) **Report:** The final EPPD document generated by SpeedExs.

10) **Admin:** A user account with the access to view and modify all the Task and assigns Task to both Regional and Single Sign On user. He/she also has the permission to add or modify any Pre-defined equipment and its algorithm.

11) **Regional users**: A user account which can be accessed by multiple users with a single user id and password. The regional user authentication method in SpeedExs allows the user to access, view and edit the Tasks allocated to the regional user account through any system.

12) **Single Sign On (SSO):** Individual person with his/her email id, if given access, can be added as SSO. The individual user will have their own credentials with the Tasks assigned

to their individual accounts in the SpeedExs. The Task assigned to a SSO user can only be viewed and edited by them.

3.2 Features in SpeedExs

This sub section provides an understanding of the software's features. Additional information, observations, and discussions about the software will be presented in subsequent chapters.

To perform a risk assessment for a site, a Task must be assigned to a user. The software's initial page displays all of the Tasks assigned to the user for conducting risk assessments for different sites, as shown in the image below figure.

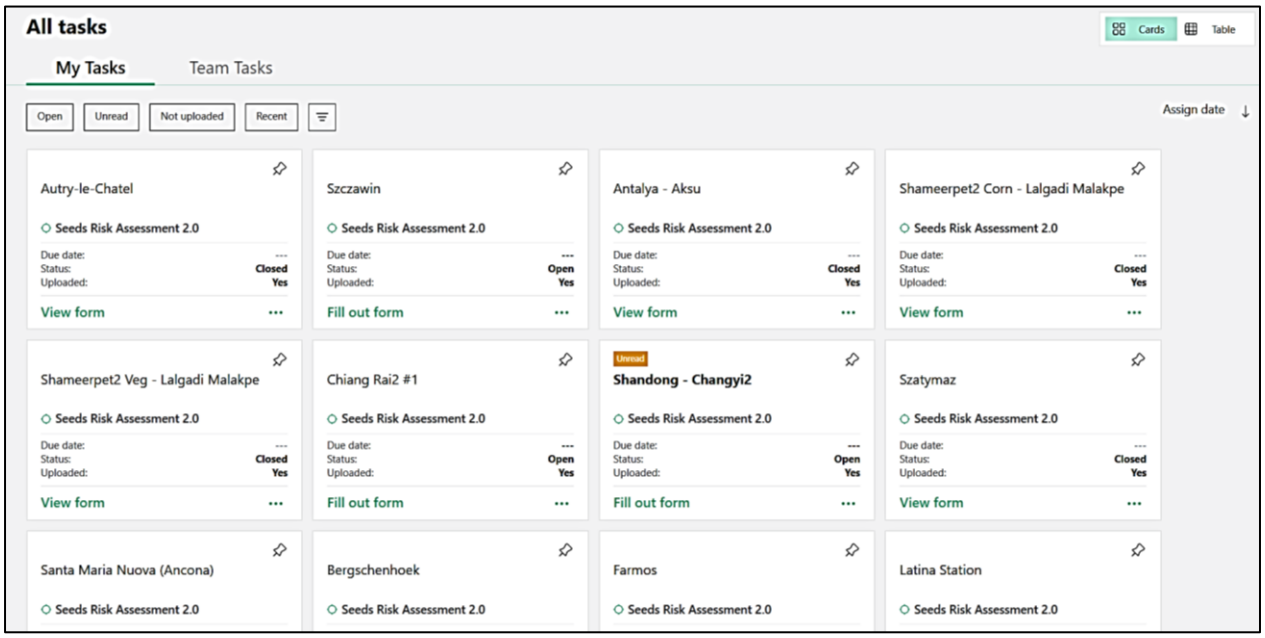


Figure 5: Screenshot of Tasks assigned to a user in SpeedExs [18]

3.2.1 Entering General Site Details

After selecting a Task, the user will be directed to the "General Site Details" page. This page prompts the user to select/enter/upload general site information and like

- Type of seeds handled at the site
- Email address
- Requirements for explosion safety
- Upload site equipment list
- Upload any additional findings
- Display the collected data

Figure 6 shows the screenshot of the mentioned fields. Further explanation/observations for the fields.

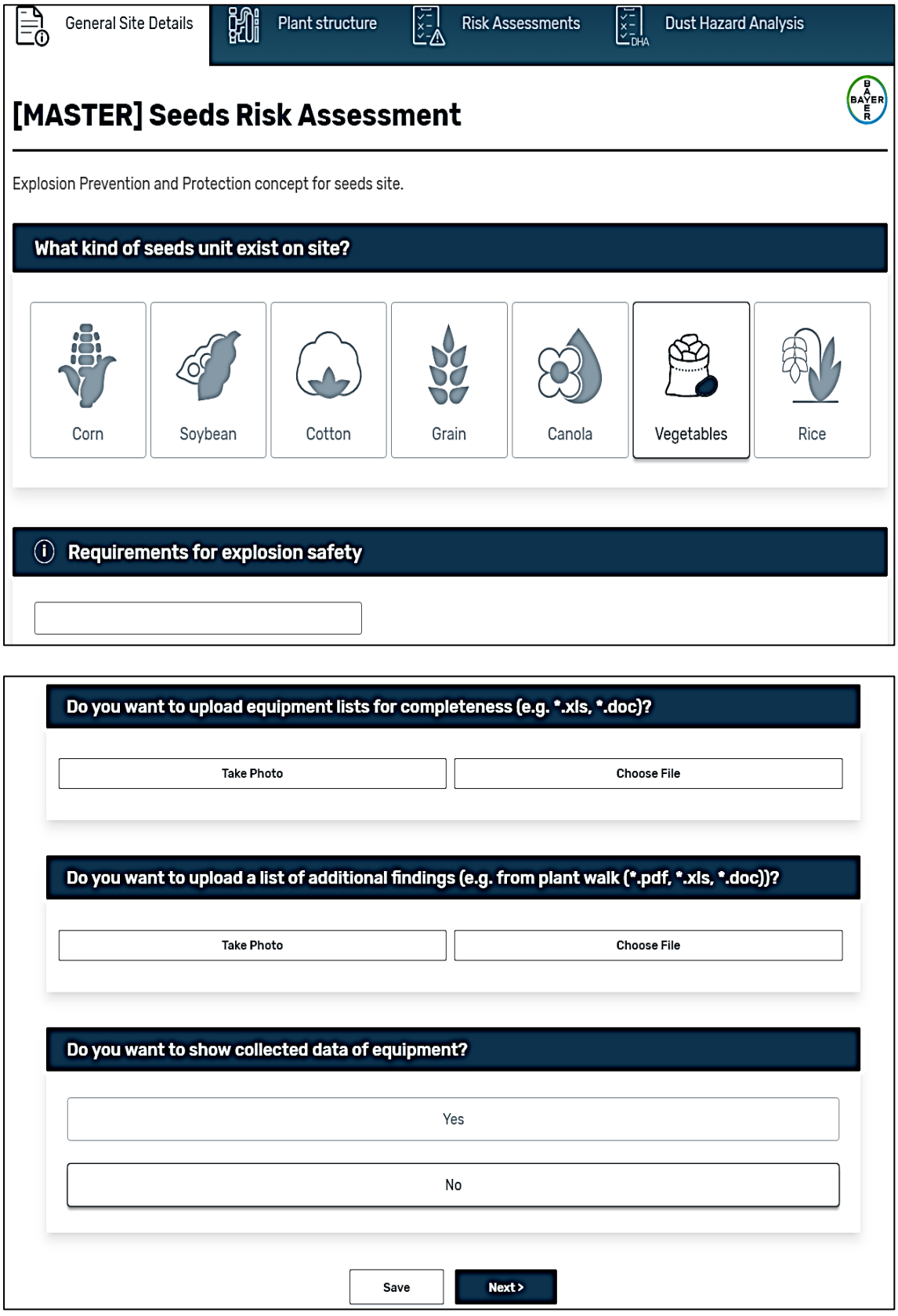


Figure 6: Screenshot of General Site Details in SpeedExs [17]

3.2.2 Defining the plant structure

The next step would be to structure site based on:

- Process
- Room

The user has an option to select the available Process whereas, the classification of equipment based on Room is user-defined. Room can be added/modified in SpeedExs for each site based on the site's requirement.

Classification based on the Room would necessitate the need for the user to submit some information, such as the location (Indoor or Outdoor), the ventilation condition (Technical or Natural), and monitoring of technical ventilation (if selected) at that site.

Also, the Figure 7 and Figure 8 illustrate, respectively, the SpeedExs "Plant structure" page based on Process and Room respectively.

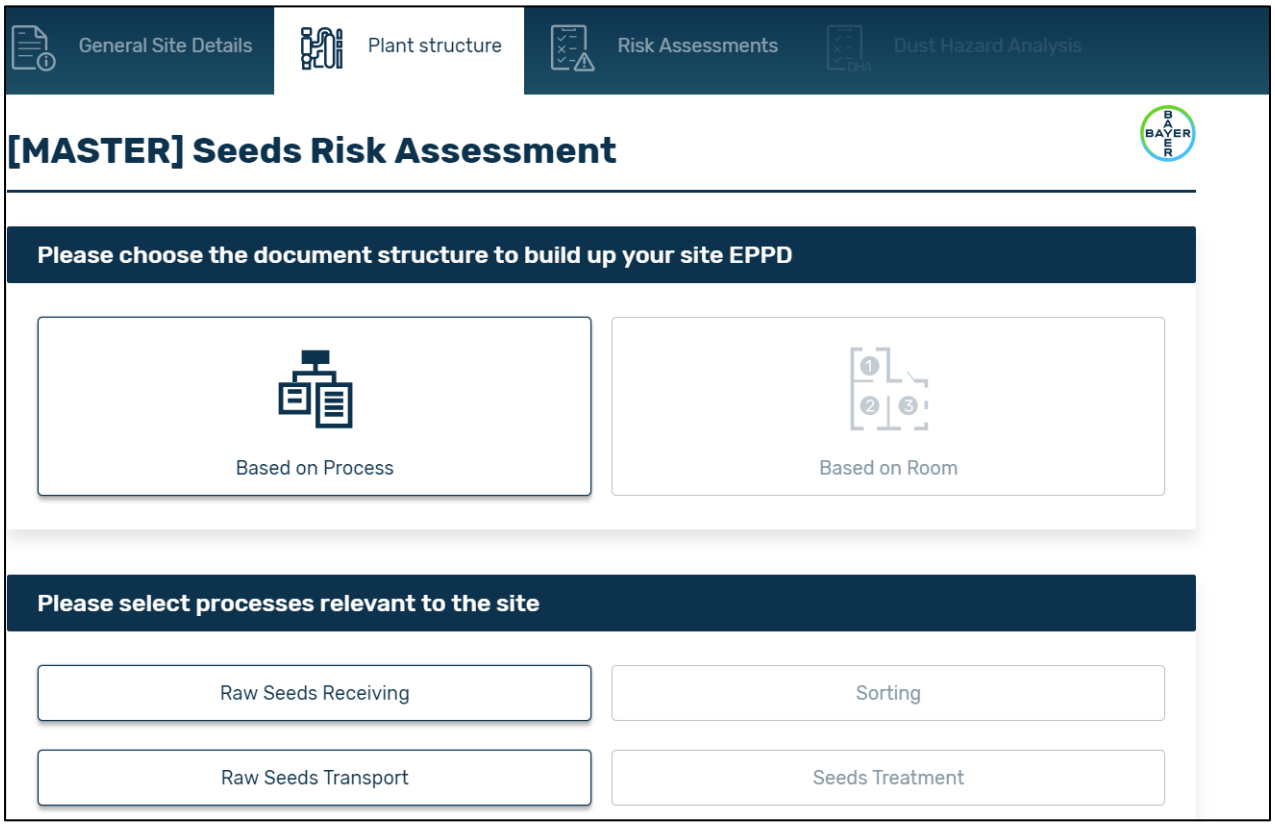


Figure 7: Screenshot of Plant structure based on Process in SpeedExs [18]

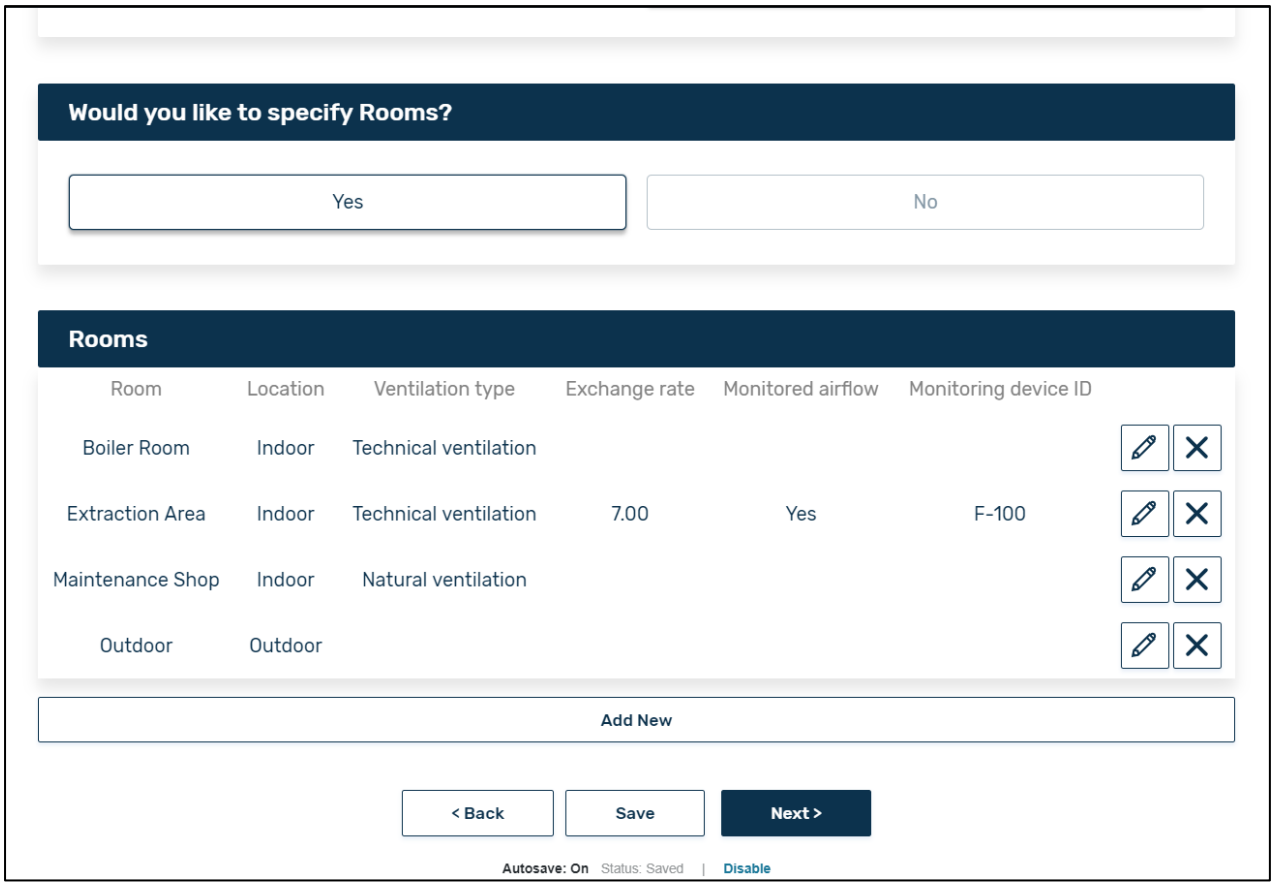


Figure 8: Screenshot of Plant structure based on Room in SpeedExs [18]

3.2.3 Adding equipment related details

Next would be to assign the site's equipment to Pre-defined equipment for which a risk assessment must be performed.

When the user clicks the ‘Add New’ button shown in the Figure 9 the field is expanded to include the explosion-safety-related equipment and its site-specific details.

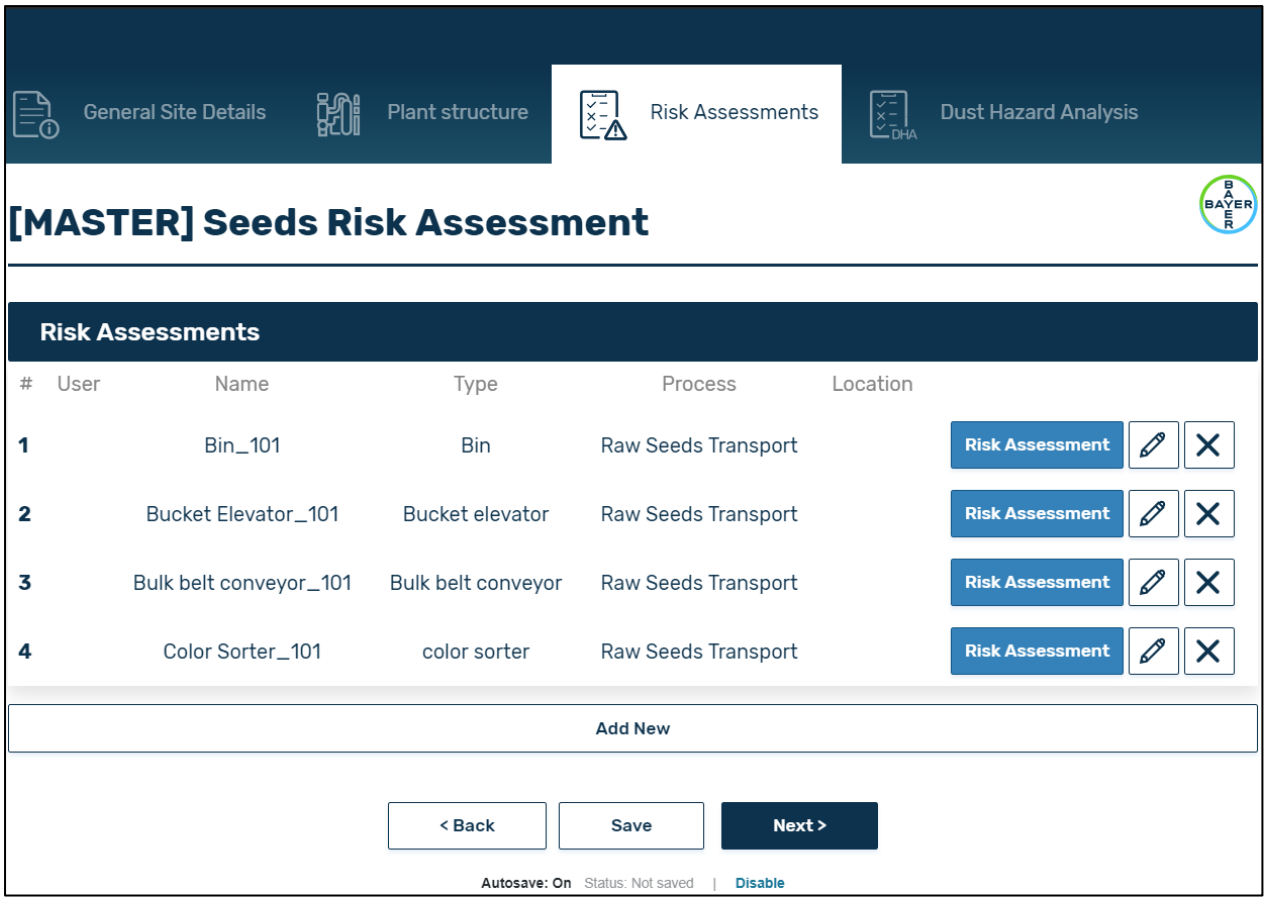


Figure 9: Screenshot of equipment added to perform risk assessment in SpeedExs [18]

The figure also shows few equipment that are assigned to Pre-defined equipment. For adding the equipment as seen in the figure, the user needs to enter equipment related details in the modal window.

The equipment specific information required to be added are

1) Process/Room in which the equipment is present
2) Type of equipment available in SpeedExs
3) Aspiration/local extraction along with respective values (if available)
4) Monitoring device for the aspiration/local extraction (if available)
5) Type of material handled in equipment (seed/utilities)
6) Name plate details such as name, manufacturer, and series number of the equipment
7) Name of substances (flammable gases/vapor or combustible dusts) handled by the equipment.

The explained equipment related details are shown as a screenshot seen in the Figure 10.

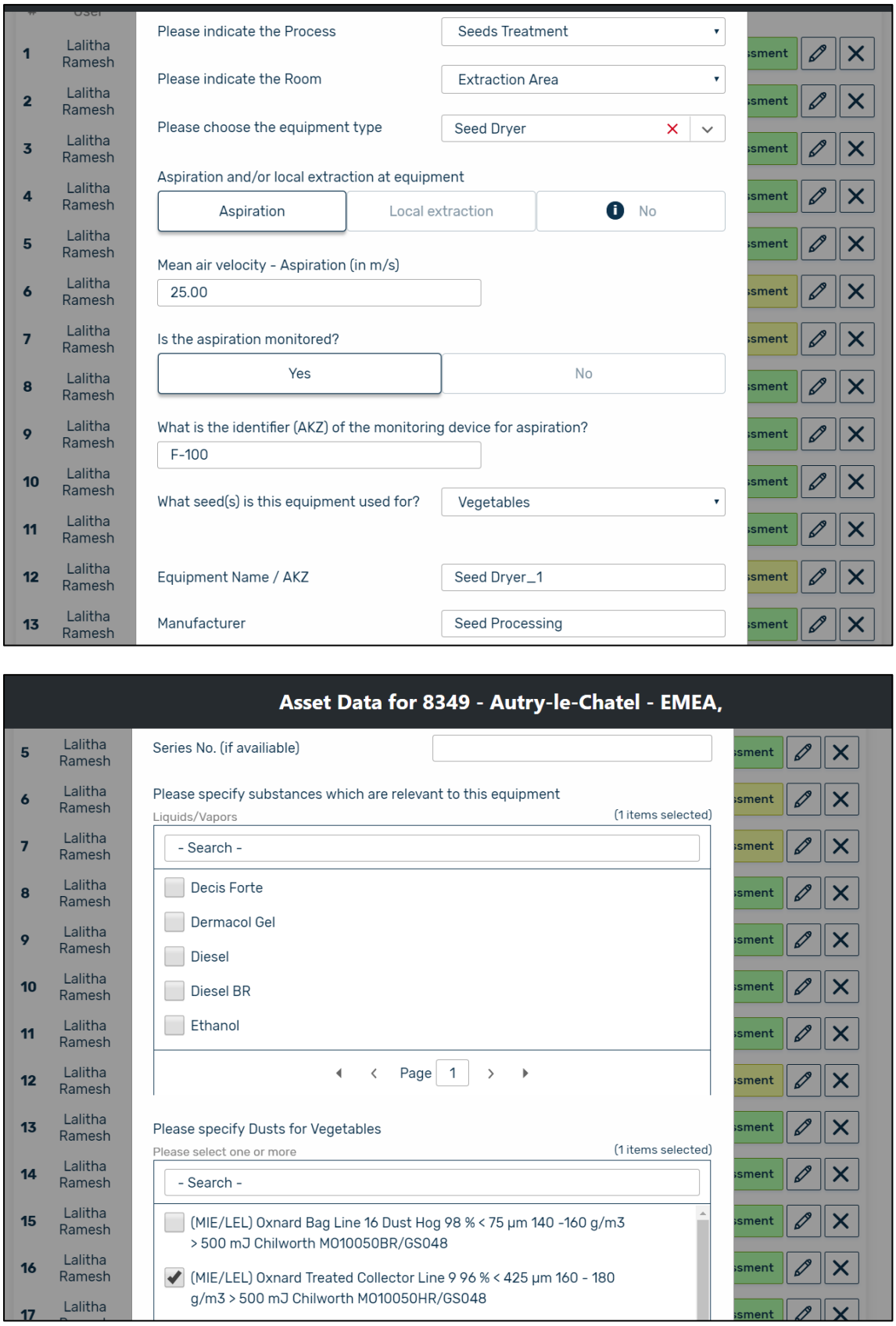


Figure 10: Screenshot of SpeedExs showing equipment specific details [18]

3.2.4 Conducting risk assessment

After adding all equipment and its details to the modal window, the user needs to do a risk assessment for all the equipment. Questions on the equipment risk assessment derived from the Pre-defined equipment algorithm document needs to be answered in order for the SpeedExs to generate zones, measures to control ignition risk and checklists in EPPD. Figure 11 shows screenshot of how the risk assessment page (Sub-form) will look like in SpeedExs.

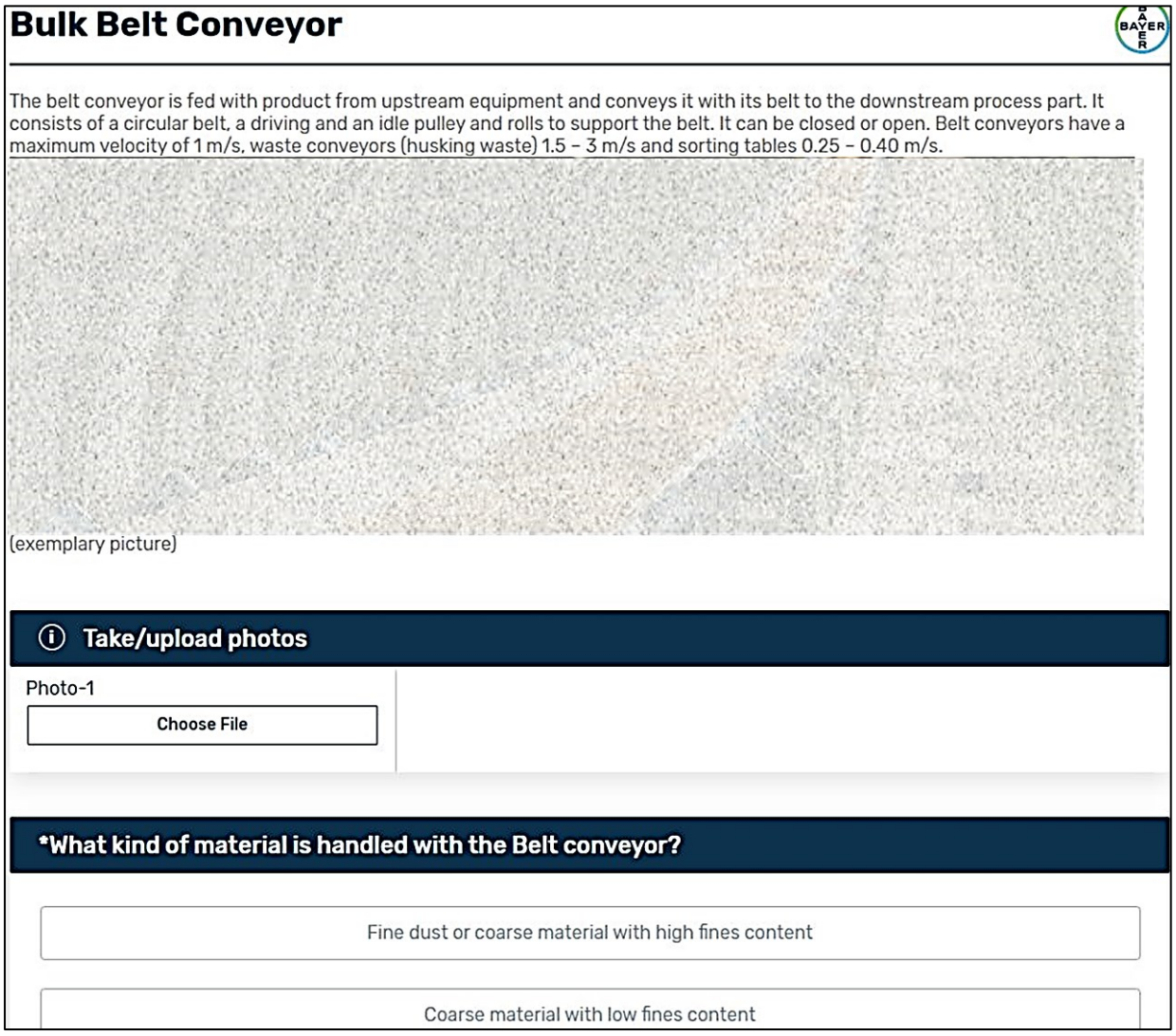


Figure 11: Screenshot showing sub-form of Bulk Belt Conveyor in SpeedExs [18]

**The image of the Bulk Belt Conveyour is blurred due to copyrights.*

User can also examine the risk assessment status for each equipment. The risk assessment for equipment that has not been started will be represented by a blue icon, the assessment that has been started but not all mandatory questions have been answered by a yellow icon, and the assessment that has been completed by a green icon. Different status of the equipment is shown in the below Figure 12 for understanding.

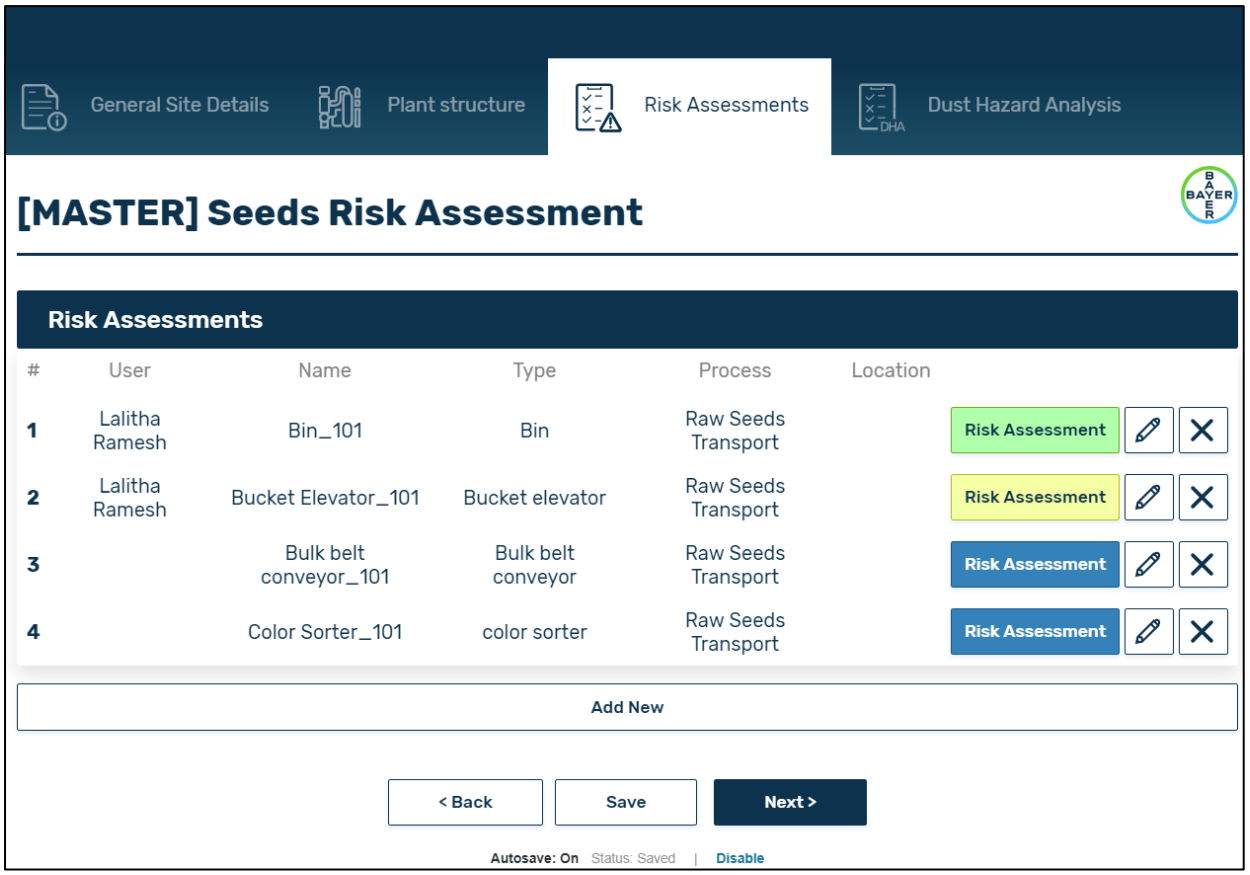


Figure 12: Screenshot of equipment's risk assessment status in SpeedExs [18]

3.2.5 Closing the Task and generating the report

Once the risk assessment is finished for all the equipment, the user can move to the Dust Hazard Analysis (DHA) section by clicking 'Next'. DHA is applicable only for the US sites, as shown in the Figure 13. Upon closing the Task, a report will be generated and sent directly to the user's email. With this the Task will come to an end. Once the Task is closed, the SpeedExs automatically generates EPPD report in the Pdf format. The observations and discussions on the generated report, as well as more detailed information on the software and its functionality, will be presented in the upcoming chapters.

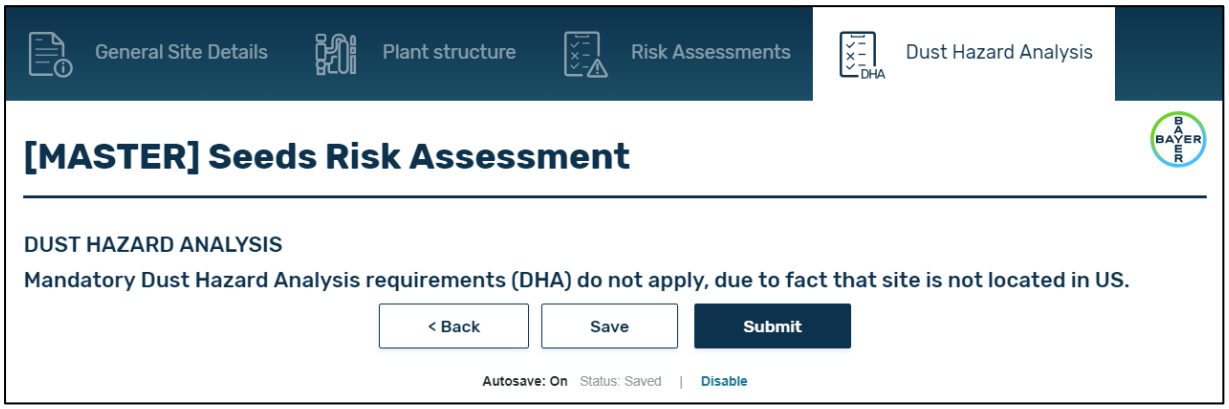


Figure 13: Screenshot of DHA page in SpeedExs [18]

4 Methodology for conducting risk assessment in sites

In this chapter, the method followed for conducting risk assessment using SpeedExs is explained in 8 steps. Following Figure 14 shows the process overview as followed by me across the 20 seed sites of EMEA region. These steps are developed based on the available resources like, Lenovo ThinkPad X13 Yoga Gen1 - Windows OS with i5 Processor, 16 GB RAM and 254 GB storage, a Sony digital camera, and explosion safety related documents from the sites.

Out of the 20 sites assessed, 18 sites were visited physically and 02 were remotely assessed. The two sites were assessed remotely due to travel restrictions however, the methodology for the remote risk assessment remined same as described in the below process flow except in event of physical field tour, a live video stream was utilized to analyse the sites remotely.

For the Complex sites, due to their complexity, a part of the assessments (Step 2 and Step 4) was carried out in collaboration with a third-party contractor (TÜV-SÜD) to evaluate the SpeedExs risk assessment's output, which included verifying the zones generated, validating the action item lists, and reporting findings relevant to explosion safety.

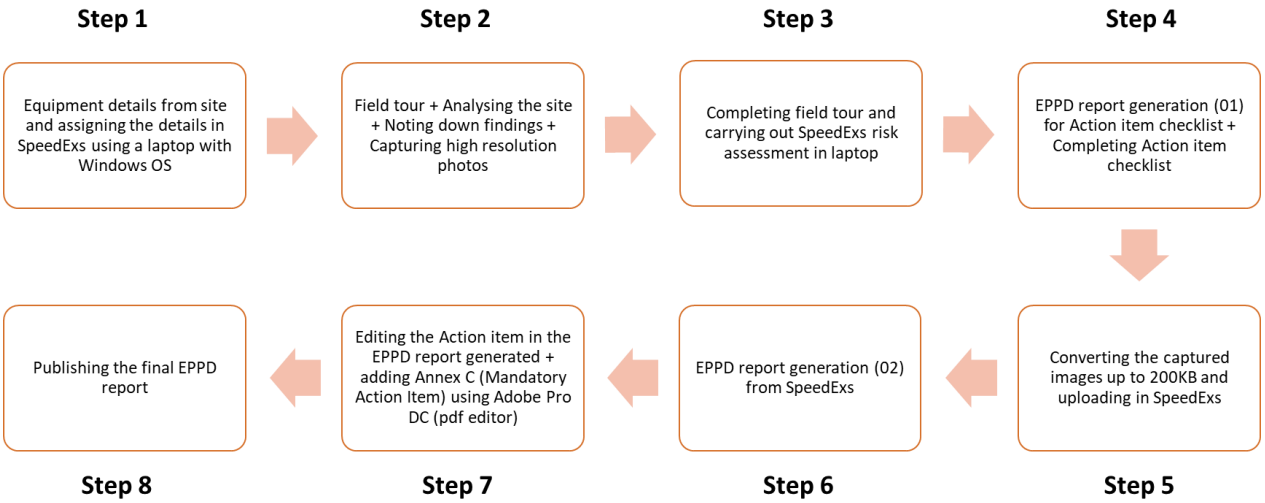


Figure 14: Process overview for risk assessment

Step 1: An official request is issued prior two weeks notifying the site of the intended visit and seeking relevant documentation such as a list of flammables, equipment list, and any other relevant documents related to explosion safety. If the site provides an equipment list, the explosion safety-related equipment will be identified and uploaded into SpeedExs using a laptop running on the Windows operating system. Otherwise, while carrying out the field tour (as mentioned in Step 2) the equipment list will be identified and finalised.

Step 2: A site tour is conducted in order to comprehend the process involved in site while simultaneously analysing the equipment, noting down the general safety-related observations and capturing high-resolution photos of the equipment. The site personnel are inquired about the working principles of various equipment related to explosion safety, which is a crucial component of the site tour, as it aids in understanding the operation philosophy and helps in allocation of Pre-defined equipment to a Site-specific equipment in SpeedExs.

Step 3: After completing the site tour, any additional changes in the equipment list shared earlier (Refer Step 1) will be adjusted and data like ventilation, aspiration/local extraction details, safety data of flammable liquids/gases, combustible dust data are added. After updating the site and equipment details in SpeedExs, the site condition is recollected from the captured photographs and the risk assessment is carried out on individual equipment in Windows OS laptop. This activity is performed in site office.

Step 4: After completing the risk assessment in SpeedExs, the EPPD report is generated (Indicated with 01 in process flow) and printed. Again, a field tour is carried out and the site is assessed using the Action item checklist with the input from site personnel for the details like equipment inspection and maintenance data. Upon completion of this activity, the site visit is officially closed.

Step 5: Upon returning to the main office at Bayer-Leverkusen, the subsequent task involves converting high-resolution images taken during the site visit to a lower resolution of up to 200KB. These images were then added to each equipment in SpeedExs by reopening the respective risk assessment forms.

Step 6: The subsequent step involves generating the EPPD report again after uploading the images into SpeedExs, as denoted by number 02 in the above-mentioned process flow.

Step 7: The Action item checklist hardcopy which was manually filled will be used as an input for replicating the Action item checklist in the EPPD report. If the site does-not comply with any of the points in Action item checklists, they are raised as Mandatory Action Items for implementation. Additionally, the unfulfilled Action items are compiled in an excel sheet and is converted to pdf which then added as Annex C in the final report. All these changes are done using Adobe Acrobat Pro DC.

Step 8: Once the report is completed, it is sent to the explosion safety experts for approval. Upon their approval, the report is considered final and then distributed to the site.

5 Results

This chapter presents the results of the assessment conducted on 20 sites, including the use of the SpeedExs application, the generated EPPD report, and compliance with regulatory requirements. At the beginning of each sub-heading, a reference is provided wherever applicable, that directs the reader to the relevant discussion based on the corresponding chapter.

5.1 Status of the Assessment

This thesis involved the assessment of 20 sites, and Table 3 provides an overview of their status. The subsequent sub-chapters present the results based on the data collected from these sites.

Refer sub-chapter 6.2 Discussion on status of assessment for discussion on this sub-section.

Table 3: Overall status of assessment

S. No	Bayer site name	Status			
		Field tour and Risk assessment	**Report generation**	**Site verification using Action item checklist**	**Publishing final report with Mandatory action items**
1	Wageningen	✓	✓	✗	✗
2	Nimes	✓	✓	✓	✓
3	Sinesti **(Complex Site)**	✓	✓	✓	✓
4	Boissay	✓	✓	✓	✓
5	Monbequi	✓	✓	✓	✓
6	San Nicolas	✓	✓	✓	✓
7	El Ejido	✓	✓	✓	✓
8	Nijar	✓	✓	✓	✓
9	Murcia	✓	✓	✓	✓
10	Santa Maria Nuova	✓	✓	✓	✓
11	Olmeneta	✓	✓	✓	✓
12	Latina	✓	✓	✓	✓
13	Farmos	✓	✓	✓	✗

S. No	Bayer site name	Status			
		Field tour and Risk assessment	Report generation	Site verification using Action item checklist	Publishing final report with Mandatory action items
14	Szatymaz	✓	✓	✗	✗
15	Antalya	✓	✓	✓	✗
16	Mustafakemalpasha **(Complex Site)**	✓	✓	✗	✗
17	Bergschenhoek	✓	✓	✓	✗
18	Autry	✓	✓	✓	✗
19	Teradion **(Remote Assessment)**	✓	✓	✓	✗
20	Potash, Uman **(Remote Assessment)**	✓	✓	✓	✗

5.2 SpeedExs application

To facilitate readers' comprehension, the results from the SpeedExs application are divided into three subsections. Each section provides an overview of the collected findings from the site assessments.

1. General Site Details
2. Plant Structure
3. Risk Assessment

5.2.1 General Site Details

The General Site Details section serves as the foundation for the EPPD and is an essential first step in conducting risk assessments. The discussion for this section is found in the sub-chapter 6.3.1 named Discussion on General Site Details in SpeedExs

This section includes the following fields

1. **The selection of Site Location *:** This field was utilized for the sites visited

   A field which describes the asset location / address and is created by the admins and not the end users. The end user can only select the Location as part of initiation of assessment.

2. **Entering email address*:** This field was utilized for the sites visited

   Email Id of the assessor, at the end of the Risk assessment the EPPD report was auto forwarded to this email address and was verified.

   A mandatory field for regional user and not for Single Sign-on user.

3. **Selecting the seed unit *:** This field was utilized for the sites visited

   Option to choose multiple Seed units for a single site as per the site process requirements.

   The below Table 4 shows the number of sites being assessed handling different Seed units:

Table 4: Seed units handled in the assessed sites

S. No	Seed units	No. of sites
1	Vegetables	13
2	Corn	04
3	Corn and Canola	02
4	Vegetables and Corn	01

4. **Requirements for explosion safety:** This field was not utilized for the sites visited
5. **Upload equipment lists:** This field was not utilized for the sites visited

   As explained in the methodology of process flow, Step 1 involved in obtaining an equipment list from the sites in order to prepare for the assessment prior to visiting them. Out of the 20 sites, the following 5 sites were able to provide the equipment list. Discussion on this section

   a) Nimes
   b) Wageningen
   c) Teradion
   d) Potash
   e) Autry

6. **Upload a list of additional findings:** This field was utilized for the sites visited

This field was used to upload an excel file containing additional findings related to explosion safety and general HSE which were identified during the field tour. This sheet also contains mandatory action items which needs to be implemented by the site. Further results on mandatory action items are explained in the sub section 5.3.8.3 Annex C.

7. **Display collected data of equipment:** This field was not utilized for the sites visited

Initially this field was not available and was recently added in SpeedExs.

If selected Yes, the equipment data like the name plate details, the risk assessment question and the answer selected in the assessment will be captured in the EPPD report as Annex D.

NOTE:

* **In the above points indicates mandatory field for Assessment**

Red field indicates the fields which were not utilised.

Green field indicates the utilised fields.

5.2.2 Plant Structure

This site, its equipment and the activities in the site are structured in EPPD based on the input provided under this section in SpeedExs. Refer sub-chapter 6.3.2 titled Discussion on Plant Structure Classification for further discussion.

5.2.2.1 Plant structure classification

Plant structure classification for the visited sites were based as below:

a) On pre-defined Process and Room for small and medium sites

b) Only Room for complex sites

The below Table 5 shows the number of sites based on the above-mentioned classification.

Table 5: Plant structure classification in sites

S. No	Sites	Structure	No of sites
1	Small and Medium	Pre-defined Process and Room	18
2	Complex	Only Rooms	02

5.2.2.2 Assigning Process and adding Rooms in SpeedExs

The below Table 6, shows the list of pre-defined Process as used in SpeedExs

Table 6: Pre-defined Process available in SpeedExs

Pre-defined Process	
Raw seeds receiving	Sorting
Raw seeds transport	Seeds treatment
Pre – cleaning	Filling and packaging
Fine cleaning	Clean seeds storage
Clean seeds transport	Utilities

The selection of the appropriate combination of processes mentioned above is based on the specific activities occurring at each site, and it is not possible to modify the predefined processes, nor is it possible to add new ones.

Nevertheless, the Room option was customizable and utilized to categorize a group of equipment under a particular area or location, as found in each site.

During the process of adding Rooms, there is an option to choose between Natural or Technical ventilation types.

No further selection or entries were necessary for sites with Natural ventilation, but for sites with Technical ventilation, the Air Exchange rate was requested.

Technical Ventilation values = Number of Air Exchanges per Hour (1/h)

For the applicable sites, the technical ventilation was added as **1.0** air exchange per hour.

The below shows the sites in which this value was considered.

Table 7: Technical ventilation value for the site

S. No	Site Name	Room	Technical Ventilation Value
1	Bergschenhoek	E 14	1.00
		E 15	1.00
		Biochemistry Lab	1.00
		Seed Health Lab	1.00
		First Floor Labs	1.00
		Seed Physiology Lab	1.00
		Seed Operations Area	1.00
		Organic Operations Area	1.00
		Operations Warehouse	1.00
2	Boissay	Lab HPLC	1.00
		HD Lab	1.00

5.2.3 Risk Assessment

To know more detailed discussions on each of the sub-chapters mentioned, refer to Chapter 6.3.3, which is titled "Discussion on Risk Assessment". This chapter provides comprehensive explanations on the risk assessment process, including the sub-components of SpeedExs, such as adding equipment, entering equipment-related details in a modal window, and conducting risk assessments for each equipment.

5.2.3.1 Assigning Equipment

The below Figure 15 explains how Predefined equipment and Generic seed equipment would appear in SpeedExs as seen under the column – Type.

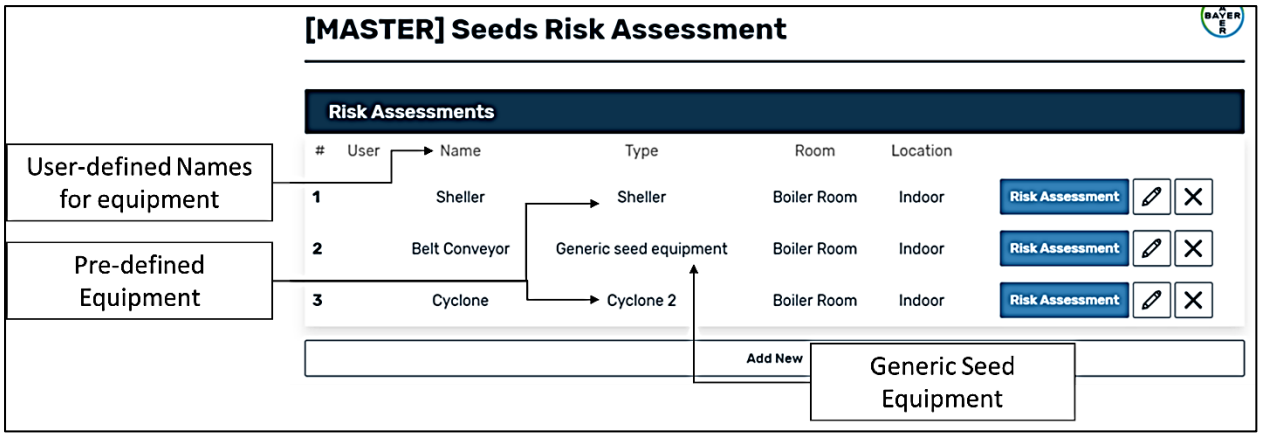


Figure 15: Screenshot showing type of Equipment in SpeedExs [18]

Below table shows the number of equipment assigned in SpeedExs based on the classification equipment 'Type' (Refer Figure 15 for an illustration of how equipment appears in SpeedExs.).

Table 8: Total no. of site-specific equipment assigned to a Pre-defined equipment

S. No	Total no. of Site – Specific Equipment assigned to Pre-defined Equipment in SpeedExs (20 sites)	
01	Pre-defined Equipment (39)	487
02	Generic Seed Equipment (1)	75

5.2.3.1.1 Use of Pre-defined equipment as Site-specific equipment

As can be seen in Table 8 there are 39 Pre-defined equipment which were used for 487 Site-specific equipment.

Except the list of equipment mentioned in Table 9 the rest of the equipment had Pre-defined equipment in SpeedExs with exact same working principle of site-specific equipment.

In case of the list of equipment mentioned in the table below, the Pre-defined equipment is used for different site-specific equipment because they have similar working principle which were figured out during the site tour. This way of using of Pre-defined equipment was because of comprehensive understanding of the working principles of both the Pre-defined and Site-specific equipment types of equipment. (Refer 6.3.3.2 Discussion on Pre-defined equipment for further discussion and examples on this sub-chapter)

Table 9: List of Pre-defined equipment used for site-specific equipment with similar working principle

S. No	Site	Site Specific Equipment	Pre-defined Equipment
1	Nimes	Indent Cylinder	Gravity Separator
2	Nimes	Air Seed Cleaner and Separator (Before precleaning)	Pre cleaner
3	Bergschenhoek	Air Seed Cleaner (After precleaning)	Sizer
4	Bergschenhoek	Seed Clipper	
5	Wageningen	Seed Clipper	
6	Wageningen	Zig Zag Separator	
7	Bergschenhoek	Seed Polisher	Fine cleaner
8	Wageningen	Rubbing Machine	
9	Nimes	Vacuum Transport System	Pneumatic Transfer System
10	Mustafakemalpasha	Mobile dryer transferring system	

5.2.3.1.2 Use of Generic Seed Equipment as Site-specific equipment

That equipment that needs to be in EPPD report but does not fall in any dust Zone can utilise this equipment type. However, an option for selecting dust zone classification (Zone 20, Zone 21, Zone 22 and No Zone) was given for Generic seed equipment.

Therefore, during the field evaluation, this category was temporarily used to add equipment that was missing from the pre-defined list of equipment.

Following Table 10 shows the list of Equipment added in Generic Seed Equipment across various sites.

Table 10: List of Generic seed equipment used for site-specific equipment

S. No	Site location	Equipment added as Generic Seed Equipment	Number of equipment	Identified zone inside the equipment
1	Nimes	Box Turner	2	Zone 22
2		Sealer for Vegetables	1	No Zone
3		Seed Counter	2	No Zone
4	Olmeneta	Seed Counter	4	No Zone
5		Seed Treater	2	Zone 22
6	Monbequi	Seed Treater	1	Zone 22
7	Farmos	Box Turner	5	Zone 22
8		Box Turner	10	No Zone
9		Seed Blender	1	No Zone
10	Wageningen	Potting Machine	1	No Zone
		Big Bale Breaker	1	No Zone
		Dibbling Machine	1	No Zone
11	MKP	Belt Conveyor	8	No Zone
		Compactor	4	No Zone
		Intake Pit	1	No Zone
		Husker	4	No Zone
		Sorting Table	10	No Zone
		Static Dryer	8	No Zone
		Seed Treater	8	Zone 21
12	Bergschenhoek	Dust Filter	1	No Zone
Total number of Generic Seed Equipment used			**75**	

5.2.3.1.3 Assigning a Site-specific equipment in SpeedExs

When any equipment needs to be added in SpeedExs, the below details are asked to enter. (Refer the Figure 10 for screenshot showing all the equipment details to be added.)

1 Specifying Process/Room: Selecting the relevant Process and Rooms are mandatory based on their selection in the Plant Structure window of SpeedExs.

2 Choosing equipment type: A mandatory field used to select from the list of Pre-defined equipment or add as a Generic Seed equipment. Here, the process of assigning site-specific equipment to a Pre-defined equipment takes place.

3 Equipment Name: This name will override the pre-defined equipment name. This field was utilised for all the equipment since it is a mandatory field.

4 Manufacturer and Series Number: These field were not mandatory and was utilized for the

equipment wherever the detail was available.

5 Aspiration & Local extraction details

The velocity of air in the aspiration/local extraction lines becomes mandatory when the user selects Aspiration and or Local extraction for the equipment

a. Mean Air Velocity for Aspiration line = Velocity of Air in the Aspiration line (m/s)

b. Mean Air Velocity for Local Extraction = Velocity of Air in the local extraction (m/s)

For the applicable sites, the Aspiration/Local extraction was added as **1.0** m/s (dummy value) as shown in the Table 11 below.

Table 11: Aspiration values of equipment of various sites entered in SpeedExs

S. No	Site Location	Number of Equipment with Aspiration/Local Extraction	Aspiration/Local Extraction Value entered for the Equipment
1	Boissay	3	1.00
2	Olmeneta	8	1.00
3	Monbequi	3	1.00
4	Sinesti	1	1.00

6 Substances relevant to equipment (SDS):

This was not a mandatory field.

During the field assessment it was observed that more safety data of flammable materials which were utilised by the site needs to be added, but adding new data was not a ready option in SpeedExs. Only 09 numbers of pre-defined safety data sets were present in the software.

The missing data was collected by using the available list provided by the site are listed in the below.

Table 12: List of safety data to be added in final EPPD report

S. No	Site Location	Safety data to be added in the final EPPD
1	Boissay	• Liquid flammables like Diethyl Ether, 2-propanol (isopropyl alcohol), Acetone Fisher, Acetonitrile Fisher, Butane, Methanol, 2,2,4 trimethylpentane, Hydrogen, Propane, n-Heptane. • Solid flammables like Lentagran, Microthiol Special Dispersers, Sephadex A-25 Chloride form
2	Monbequi	• Butane, Propane
3	Bergschenhoek	• Liquid and gaseous flammables like Hydrogen, Methanol, Ethanol 98%, Ethanol 80%, 2-Methyl-1-Butanol, Ethanol 70%, Isopropanol, Acetone, Gasoline, Ethyl Acetate, Burning spirit 85%, Thinner, Acetic acid 80%.
4	Nimes	• Mixture of dust from seed like squash, pepper, cucumber, lettuce, spinach, carrot, onion. • Liquid flammables such as Chlorpham TX Herbicide, Karathane 30 fungicide, Pyrathroid insecticide, pearl expert insecticide.
5	Antalya	• LPG.
6	Teradion	• LPG

7 Dust handled in site:

A non-mandatory field and new dust data cannot be added manually in the software but can be added only by admin.

During the assessment across the various sites, it has been found that only **Bayer - Bergschenhoek** had the safety data for dusts produced based on the dust data analysis carried out by the external contractor.

However, the SpeedExs had 64 pre-defined safety data sets from NFPA 61, BIA report 97 and various other sites. But these data selection were not used as many of the data were without proper name to identify the substance and its properties and also the interface lacked the Filter option to select the respective site-specific data instead and only a search option was available.

The Figure 16 shows some of the dust data taken from Cotton, Canola and Rice. Discussion on the safety data can be found in the sub-chapter 6.3.3 Discussion on Risk Assessment under chapter Discussion.

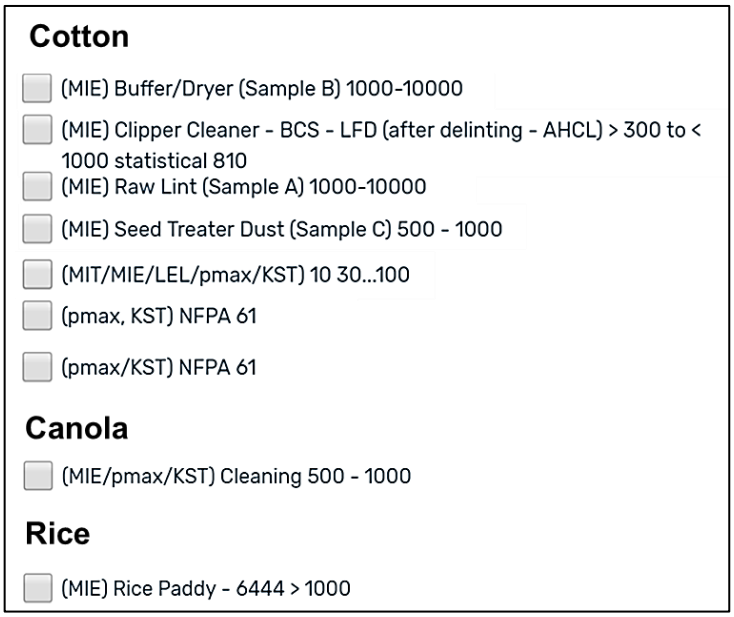


Figure 16: Screenshot of Dust data – Cotton, Canola, Rice in SpeedExs [18]

5.2.3.2 Equipment description and uploading pictures

Equipment Description describes the functioning of equipment, the operating conditions including the type of products handled.

For a Predefined equipment the description of the equipment will be shown. However, few equipment like Precleaner, Fine Cleaner, Dust Filter, Gasoline station etc didn't had any description. For Generic Seed equipment the assessor needs to add the description of equipment.

An option for uploading pictures is available for both Pre defined and Generic Seed equipment. Pictures of respective equipment were added in SpeedExs under this field even though it was not a mandatory field.

5.2.3.3 Equipment specific risk assessment questionnaire

The 39 Pre-defined equipment in SpeedExs had individual set of risk assessment questionnaires based on which zones, measures to control explosion risk and Action item checklists were generated.

For each equipment, the answers selected for its Risk assessment questionnaires led to generation of Zones for that inside and outside of the equipment.

After assigning all the equipment under the Process / Room, the risk assessment for each equipment is conducted by answering the questionnaire generated. For understanding how the background algorithm works the process flow for Cyclone, Sheller and Generic Seed equipment are explained in 6.3.3.1. Discussion on Risk Assessment Process Flow.

As previously mentioned in Table 10, 75 site-specific equipment were designated as Generic Seed equipment in SpeedExs. For this, a set of common questions such as, type of dust handled in the equipment and aspiration availability were asked to enter and dust zone classification were manually allocated based on the equipment's site specific - situation.

One of the risk assessment questionnaires for several pre-defined equipment is "Is there adequate aspiration available for the equipment?". Since Aspiration/Local extraction values were unavailable for the number of equipment in locations as listed in Table 11 the worst-case scenario was opted, i.e. 'No aspiration' is selected for this question. Few sets of questionnaires were modified based on the real time site conditions which can be seen in the below sub-section.

5.2.3.3.1 Amendment in equipment risk assessment questionnaires

Modifications were suggested to the admin and changes were made to the predefined risk assessment questionnaires based on the real time scenarios in as explained in following. The reason for the modifications is explained in the sub section 6.3.3.4 Discussion on Amendment in equipment risk assessment questionnaires

Table 13: Amended risk assessment questionnaire of equipment

S. No	Equipment	Predefined risk assessment question	Modified based on the real time scenarios
1	Safety Cabinet	Are all the vessels originally sealed, have not been opened before, no opened handling?	Are all the vessels tightly closed, no open vessels inside the safety cabinet?
2	Bin	What kind of material is processed? Available options: a) Coarse material (no dust and dust layer formation expected) b) Minor amount of fine dust in coarse material (no dust cloud, but dust layers may occur)	What kind of material is processed? Options: a) Coarse material (no dust and dust layer formation expected) b) Minor amount of fine dust in coarse material (no dust cloud, but dust layers may occur) c) Fine dust, material containing a high amount of fine dust leading regularly to a dust cloud which does not persist most of the time (<50% of the process time) d) Fine dust, material containing a high amount of fine dust leading regularly to a dust cloud persisting most of the time (>50% of the process time)

5.2.3.3.2 Change in Equipment configuration and Zone identification:

Few sites mentioned in below Table 14 had different configurations of an equipment i.e., few sub components of the pre-defined equipment are not physically present in these sites. This led to unnecessary indication of equipment components and its respective zones. Also, in few sites like mentioned in Table 15, the Zones identified were not matching with site scenario. During the physical verification, it has been observed that the site didn't have any layer or cloud of dust but the SpeedExs still provided a zone for the equipment. (Refer chapter 6.3.3.5 Discussion on Change in Equipment configuration and Zone identification for further discussion)

To overcome this temporarily, Risk assessment was carried by considering the equipment as a Generic Seed Equipment

The below table describes the changes in equipment configuration in various sites.

Table 14: Changes in equipment configurations for various sites

S. No	Location	Pre-defined equipment configuration	Actual equipment configuration	Zone identification as per pre-defined equipment configuration	Modifications based on the actual equipment configuration
1	Mustafakemalpasha	**Seed Treater:** 1. Seed hopper 2. Scale chamber 3. Treater 4. Additives hopper 5. Rotary valve	**Seed Treater:** 1. Seed hopper 2. Treater 3. Additives hopper 4. Rotary valve	No zone: Seed hopper, No zone: Scale chamber, No zone: Additives hopper and rotary valve, Zone 1/21 (hybrid mixture): Treater, No zone: outside equipment	No zone: Seed hopper, No zone: Additives hopper and rotary valve, Zone 1/21 (hybrid mixture): Treater, No zone: outside equipment **Changes yet to be implemented.**
2	Szatymaz	**Seed Treater:** 1. Seed hopper 2. Scale chamber 3. Treater 4. Additives hopper 5. Rotary valve	**Seed Treater:** 1. Seed hopper 2. Treater	No zone: Seed hopper, No zone: Scale chamber, No zone: Additives hopper and rotary valve, Zone 22: Treater, No zone: outside equipment	No zone: Seed hopper, No zone: Additives hopper, Zone 22: Treater, No zone: outside equipment **Changes yet to be implemented.**
3	Olmeneta	**Seed Treater:** 1. Seed hopper 2. Scale chamber 3. Treater 4. Additives hopper 5. Rotary valve.	**Seed Treater:** 1. Treater	No zone: Seed hopper No zone: Scale chamber No zone: Additives hopper and rotary valve Zone 22: Treater No zone: Outside equipment	Zone 22: Inside equipment No zone: Outside equipment **The generic seed equipment sub-form was used to obtain the zones.**
4	Monbequi	**Seed Treater:** 1. Seed hopper 2. Scale chamber 3. Treater 4. Additives hopper 5. Rotary valve	**Seed Treater:** 1. Treater	No zone: Seed hopper, No zone: Scale chamber, No zone: Additives hopper and rotary valve, Zone 22: Treater, No zone: outside equipment	Zone 22: Inside equipment No zone: Outside equipment **The generic seed equipment sub-form was used to obtain the zones.**

S. No	Location	Pre-defined equipment configuration	Actual equipment configuration	Zone identification as per pre-defined equipment configuration	Modifications based on the actual equipment configuration
5	Farmos	**Cyclone:** 1. Cyclone 2. Rotary valve 3. FIBC	**Cyclone:** 1. Cyclone 2. Rotary valve 3. Downstream equipment (Vibratory sizer)	Zone 21: Rotary valve Zone 21: FIBC Zone 20: Cyclone No zone: outside equipment	Zone 21: Rotary valve Zone 21: Same zone as downstream equipment, but at least zone 21 Zone 20: Cyclone No zone: Outside equipment **New Pre-defined Equipment: "Cyclone 2" was added with Risk assessment questionnaire.**
6	Bergschen hoek	**Seed Treater:** 1. Seed hopper 2. Scale chamber 3. Treater 4. Additives hopper Rotary valve	**Seed Treater:** Treater	No zone: Seed hopper, No zone: Scale chamber, No zone: Additives hopper and rotary valve, Zone 22: Treater, No zone: outside equipment	Zone 22: Inside equipment No zone: Outside equipment **The generic seed equipment sub-form was used to obtain the zones.**

The below Table 15 projects the unmatching Zones identified in each site and the changes made to meet the site scenarios.

Table 15: Corrections made in identified zone

S. No	Location	Equipment	Changes made by	Initial zone identification		Modified zone based on the real time scenarios	
				Inside Eq.	Outside Eq.	Inside Eq.	Outside Eq.
1	Mustafake malpasha	Belt Conveyor	Considering as Generic seed equipment	Zone 22	No zone	No zone	No zone
2	Bergschen hoek	Dust filter		Zone 21: Raw gas side Zone 22: Clean gas side	No zone	No zone	No zone
3	Mustafake malpasha	Static Dryer		Zone 22	No Zone	No Zone	No Zone
4	Mustafake malpasha	Intake pit		Zone 22	No Zone	No Zone	No Zone

5.2.3.3.3 Additional equipment identified for implementation in SpeedExs.

During the course of the risk assessment, it was observed that some key equipment was missing from SpeedExs. As part of my master's thesis. I was able to identify the missing workflows which are shown in the following table and reported them to the admin for implementation in the SpeedExs.

In the following list of equipment items shown in were not only missing from SpeedExs but also unable to be added as Generic Seed Equipment.

Table 16: Identified missing equipment

S. No	Equipment	Sites utilizing the process/equipment
1	Chemical handling area: handling of flammables like ethanol, fertilizers, etc.	• Autry • Bergschenhoek
2	Gas cylinders used for Butane / Propane / LPG / Acetylene etc.	• Monbequi • Boissay • Teradion
3	Bullet / cylindrical tanks for LPG/Propane storage	• Antalya • Monbequi • Mustafakemalpasha
4	Fuel lines (Natural Gas, Propane, LPG)	• Monbequi • Boissay • Bergschenhoek • Nimes • Farmos • Autry • Sinesti • Mustafakemalpasha • El Ejido • Latina • Antalya • Szatymaz
5	Truck Loading	• Sinesti
6	Seed Thresher	• Monbequi • Potash • Nimes
7	Cyclone 2	• Farmos
8	Box Turner	• Nimes • Farmos

5.2.3.4 Adding assessment Recommendations in SpeedExs

At the end of assessment questionnaire, two types of recommendation can be provided:

1. Technical Recommendation: Recommendation to have better engineering control.
2. Administrative Recommendation: Recommendation to have better administrative control

This field was not utilised in any of the sites. No recommendations were available and so the field was not used.

5.2.3.5 DHA questionnaire

A Dust Hazard Analysis (DHA), according to NFPA 652, is a formalized process for identifying and evaluating the fire, deflagration, and explosion hazards associated with dusts and particulate solids in the sites. The DHA provides recommendations to manage these hazards [18].

As a part of the risk assessment in SpeedExs, the set of DHA questionnaires are displayed automatically only if the site location is selected from any of the US'S sites. Since the sites considered for assessment in this thesis are only from the EMEA region, the DHA questionnaires were not displayed in SpeedExs.

5.3 EPPD

20 EPPD (Explosion Prevention and Protection Document) reports were generated in English language using SpeedExs. The observations made are summarised for each section of the generated report. To ensure the confidentiality of the reports from the sites, the full reports are not attached. However, to assist readers in comprehending the intended information, screenshots from the reports have been utilized in relevant sections.

5.3.1 EPPD Cover page

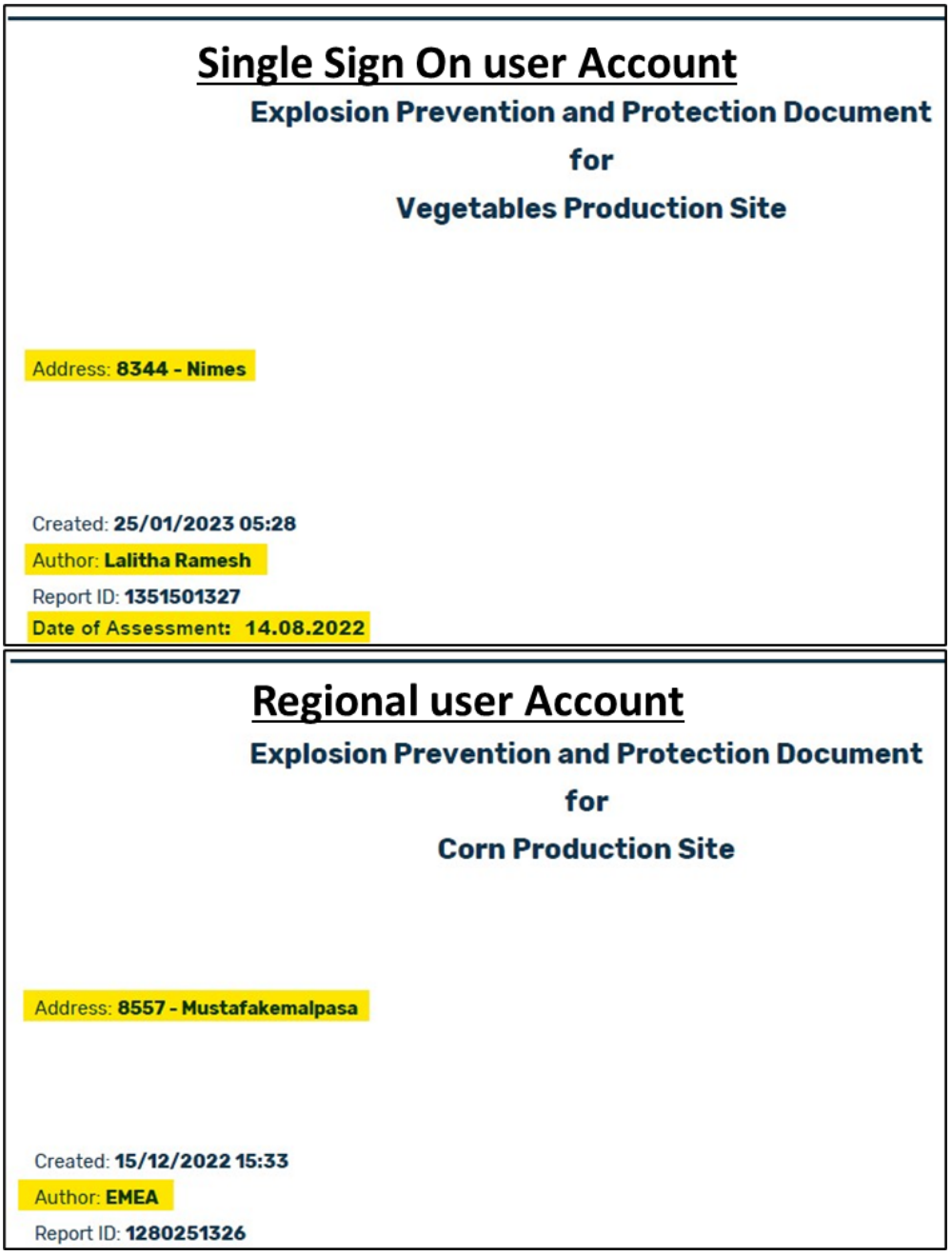


Figure 17: Screenshot of generated EPPD cover page for SSO and Regional user [20] [21]

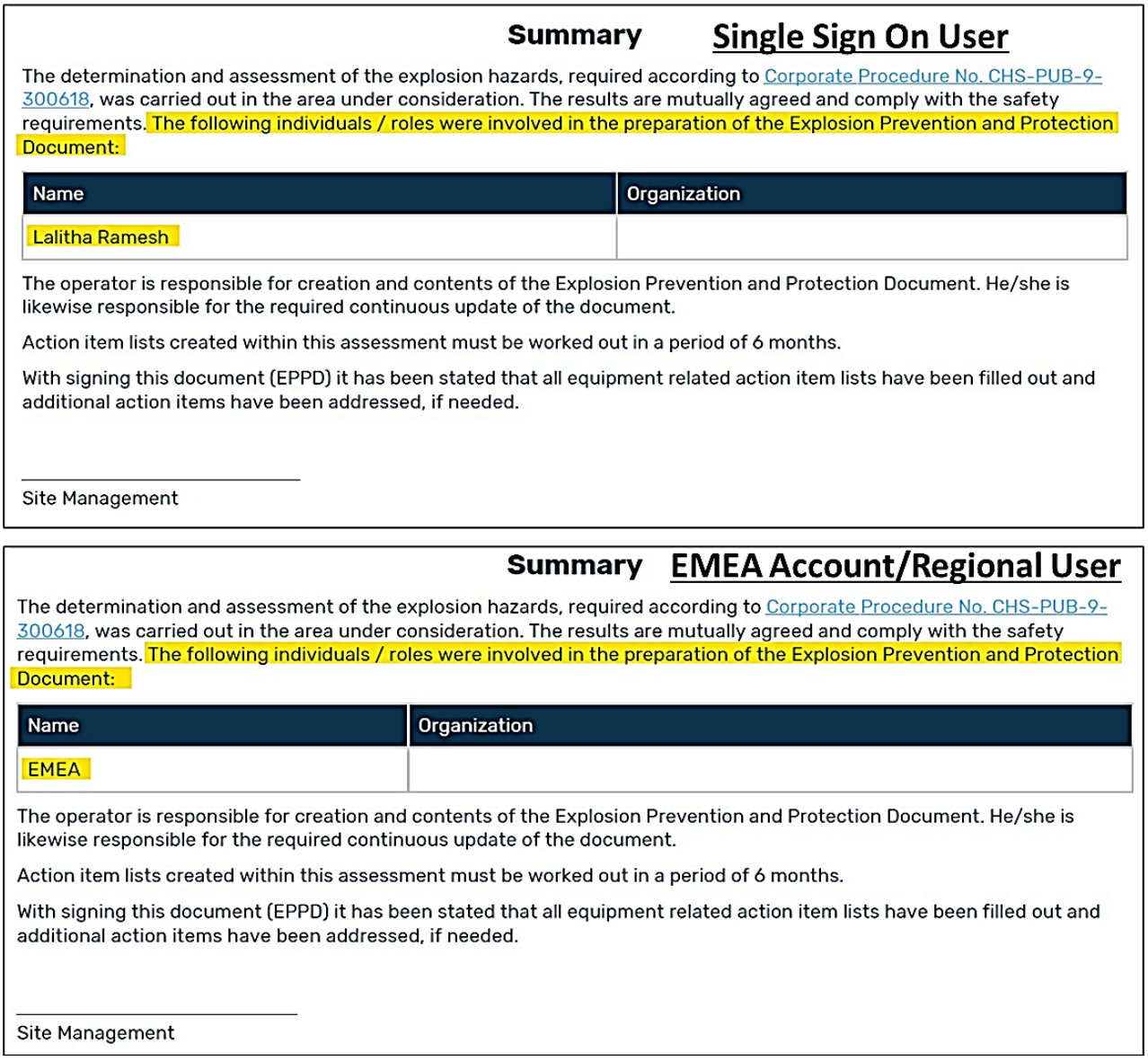
Regional user account was created in order for the third-party contractors to access SpeedExs since the SSO account creation is possible only for the people with Bayer email id.

In an SSO user account the Author of the document was the SSO user name but for a Regional user account the Author's name in the document was EMEA.

The Date of Assessment was not part of auto generated report and was not an option in both the Login IDs and was manually added using Adobe Pro DC (pdf editor).

Similarly in the 2nd page of EPPD as shown in the Figure 18, the name of the individual who did the assessment is generated as the SSO user name and the Regional user name.

The fields are highlighted in yellow in the Figure 17 and Figure 18 to aid the reader in understanding the points. The figures are screenshots from EPPD report of two different sites with different SpeedExs users.



Summary **Single Sign On User**

The determination and assessment of the explosion hazards, required according to Corporate Procedure No. CHS-PUB-9-300618, was carried out in the area under consideration. The results are mutually agreed and comply with the safety requirements. The following individuals / roles were involved in the preparation of the Explosion Prevention and Protection Document:

Name	Organization
Lalitha Ramesh	

The operator is responsible for creation and contents of the Explosion Prevention and Protection Document. He/she is likewise responsible for the required continuous update of the document.

Action item lists created within this assessment must be worked out in a period of 6 months.

With signing this document (EPPD) it has been stated that all equipment related action item lists have been filled out and additional action items have been addressed, if needed.

Site Management

Summary **EMEA Account/Regional User**

The determination and assessment of the explosion hazards, required according to Corporate Procedure No. CHS-PUB-9-300618, was carried out in the area under consideration. The results are mutually agreed and comply with the safety requirements. The following individuals / roles were involved in the preparation of the Explosion Prevention and Protection Document:

Name	Organization
EMEA	

The operator is responsible for creation and contents of the Explosion Prevention and Protection Document. He/she is likewise responsible for the required continuous update of the document.

Action item lists created within this assessment must be worked out in a period of 6 months.

With signing this document (EPPD) it has been stated that all equipment related action item lists have been filled out and additional action items have been addressed, if needed.

Site Management

Figure 18:Screenshot of generated summary of EPPD from SSO and Regional user [20] [21]

5.3.2 Table of Content

In table of content under section 6 Appendices, Annex C - Mandatory Action Items is not generated as shown in the below Figure 19: Screenshot of generated Table of Contents in Figure 19.

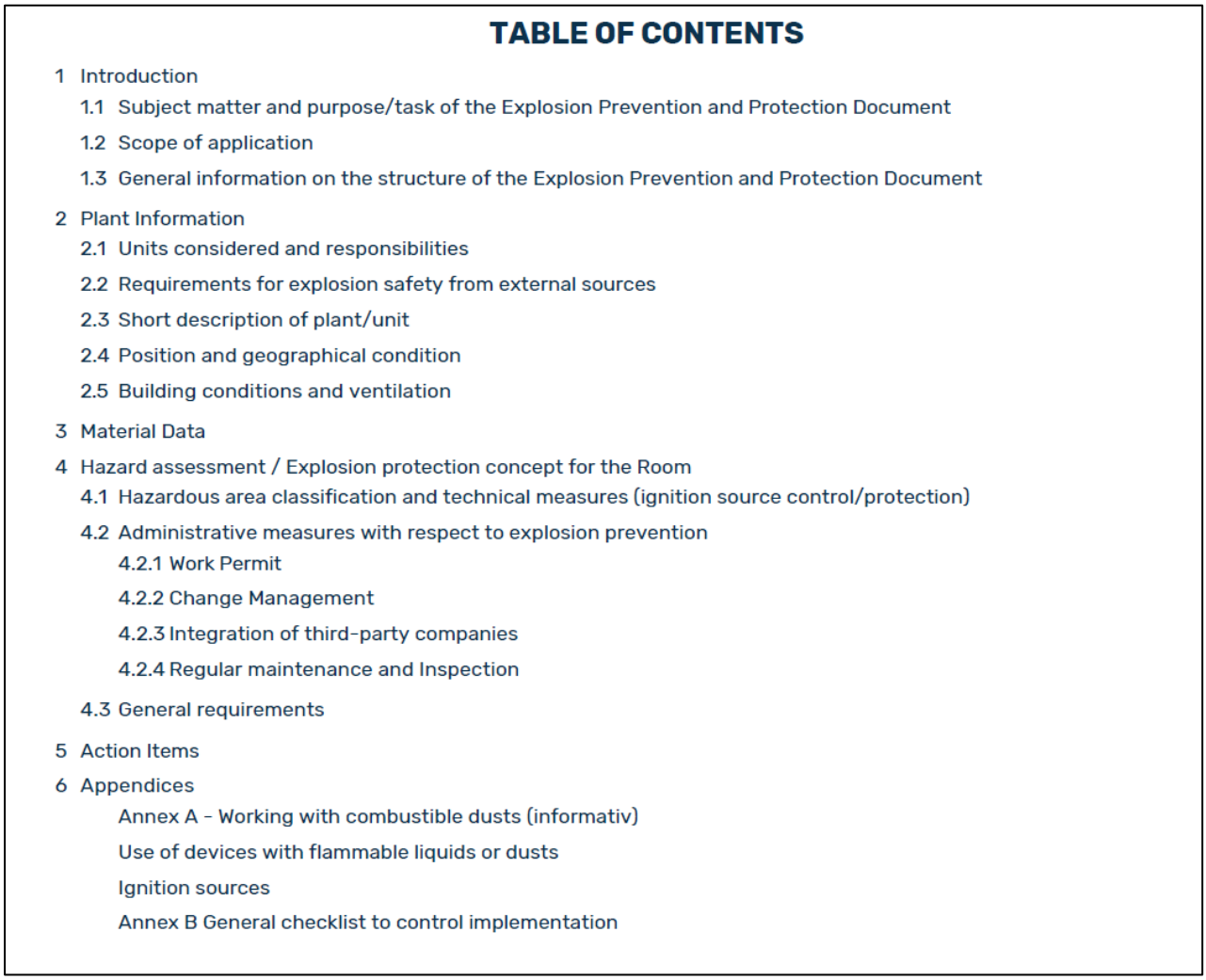


TABLE OF CONTENTS

1 Introduction
1.1 Subject matter and purpose/task of the Explosion Prevention and Protection Document
1.2 Scope of application
1.3 General information on the structure of the Explosion Prevention and Protection Document
2 Plant Information
2.1 Units considered and responsibilities
2.2 Requirements for explosion safety from external sources
2.3 Short description of plant/unit
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3 Material Data
4 Hazard assessment / Explosion protection concept for the Room
4.1 Hazardous area classification and technical measures (ignition source control/protection)
4.2 Administrative measures with respect to explosion prevention
4.2.1 Work Permit
4.2.2 Change Management
4.2.3 Integration of third-party companies
4.2.4 Regular maintenance and Inspection
4.3 General requirements
5 Action Items
6 Appendices
Annex A - Working with combustible dusts (informativ)
Use of devices with flammable liquids or dusts
Ignition sources
Annex B General checklist to control implementation

Figure 19: Screenshot of generated Table of Contents in EPPD [22]

5.3.3 Introduction

The observations of the chapters that make up the EPPD report's Introduction chapter are explained in this section.

5.3.3.1 Purpose

The following describes the purpose of EPPD in the reports generated by SpeedExs.

Table 17: Observation from Purpose generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
1.1	Subject matter and purpose/task of the Explosion Prevention and Protection Document	The purpose of the EPPD as well as the reference documents to which it complies are outlined in this section of the document. **This remains common for all the reports generated.**

5.3.3.2 Scope of application

The below Table 18 describes the scope of the EPPD in the reports generated by SpeedExs.

Table 18: Observation from Scope of application generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
1.2	Scope of application	Scope defines the asset location, the plant structure (Process and Room) with equipment list as entered in the SpeedExs software. The EPPD will be applicable for the areas mentioned here. **It is site – specific field.**

As discussed earlier in sub-chapter 5.2.2.1 Plant structure classification, out of 20 sites visited both Process and Room were used for small sites and only Room for complex sites.

In most of the sites, the generated Report projected the same sequence of order of the Plant Structure as added in SpeedExs. That is Process followed by Room and Equipment.

As an example, the below Figure 20 shows the screenshot from the report generated for **Bayer - Nimes**. The section starts with the site address and a list of all the Process / Room and Equipment for which the EPPD is applicable.

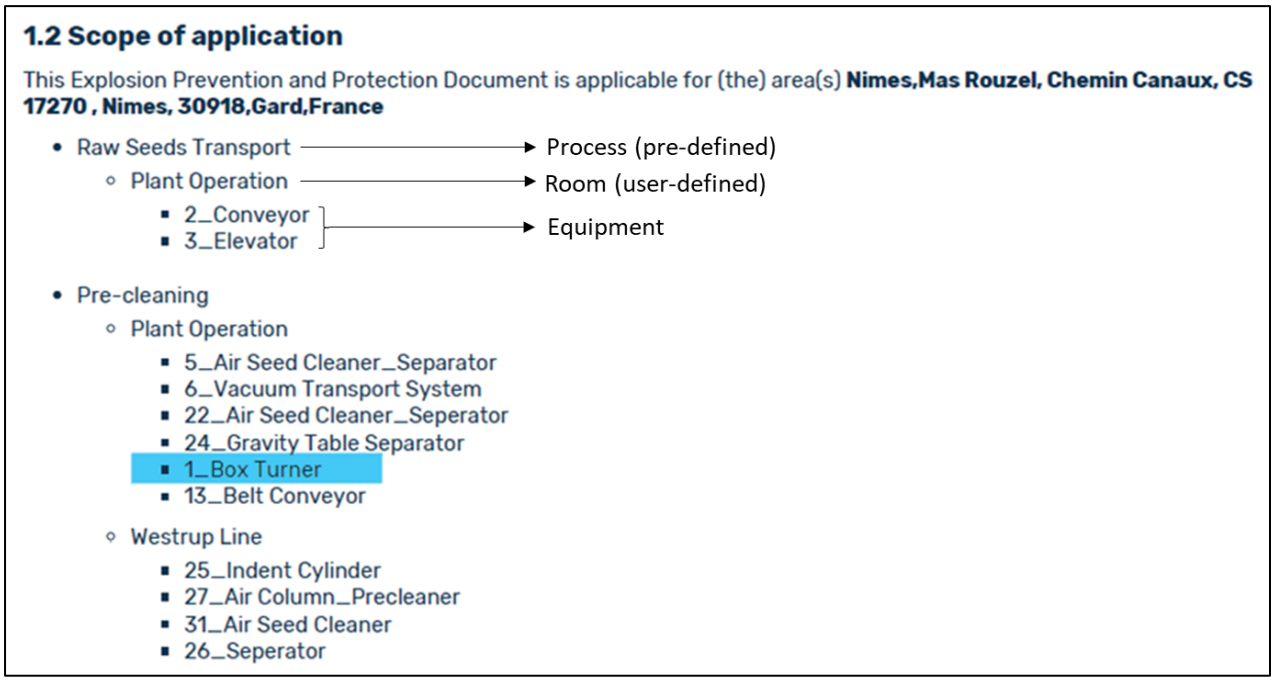


Figure 20: Screenshot of Scope of application from EPPD [20]

The Site-Specific Equipment based on the Pre-defined Equipment and Generic Seed Equipment are listed as expected, with the Site-Specific Equipment name superseding the Pre-defined Equipment name.

The equipment highlighted in blue in the above picture is a Generic Seed Equipment and the rest are Pre-defined Equipment.

Bayer - Mustafakemalpasha - Turkey, is a complex site with around 250 explosion safety related equipment. Initially, the equipment list with the corresponding Room data was provided by the site in order to do the pre work before visiting the site for assessment. That is entering the Plant Structure and Equipment data into SpeedExs. So, Room was entered and Equipment were assigned to it. Later during the site visit the Process was selected for the added data based on the observation from the site tour.

The assessment was successfully carried out in SpeedExs and Zone classifications were generated.

But, since the Room was added first, the report generated contained the classification based on Room first and then the corresponding Process was shown for every equipment.

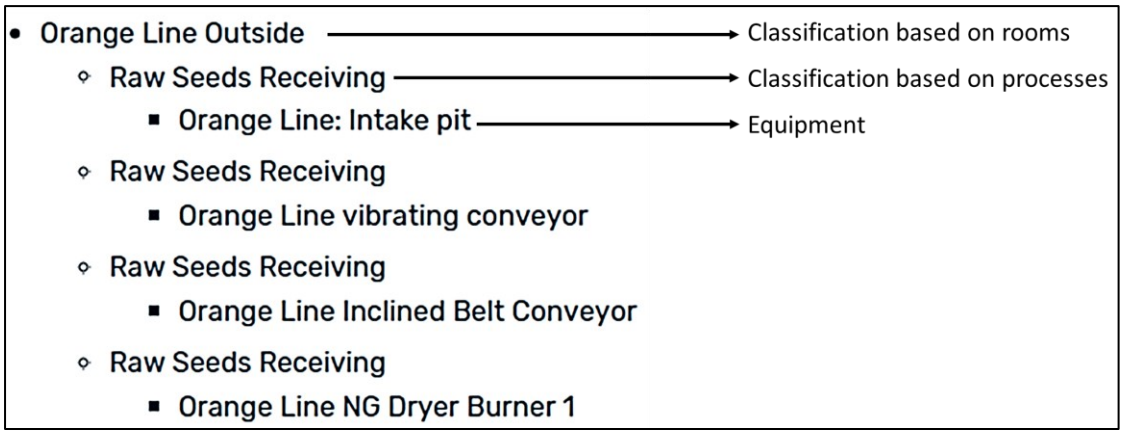


Figure 21: Screenshot of Scope of application – EPPD Mustafakemalpasha [21]

As in above Figure 21, the report was generated in the sequence of Room first followed by Process and Equipment. Also, Process was repeatedly shown for every Equipment.

5.3.3.3 Structure of the EPPD

The below Table 19 describes general information on the structure of EPPD in the reports generated by SpeedExs.

Table 19: Observations on Structure generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
1.3	General information on the structure of the Explosion Prevention and Protection Document	• A section which has the statements to the sites regarding that it could refer to other existing documents, which partially cover explosion risk assessments. This assessment relates to permanent installations and regularly occurring activities. **This remains common for all the reports generated.**

5.3.4 Plant Information

The below Table 20 describes Units considered and Responsibilities of the sites in the EPPD generated based on entries into SpeedExs.

Table 20: Observations on Units considered and Responsibilities generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
2.1	Units considered and Responsibilities	• Responsibility**:** The Operator is represented by the plant manager and, where necessary, other functions with their respective areas of responsibility. **The responsibility stated remains common for all the reports generated.** • The Units considered is a table containing the list of Process and Equipment.

The below screenshot Figure 22 shows example of the Units considered with the Process and Equipment added.

However, it has been observed that, across all the sites, the Equipment naming terminology is Predefined Equipment Name or Generic Seed Equipment + Site Specific Equipment.

The below highlighted equipment **Bulk belt conveyor - 2_Conveyor** is a combination of Predefined Equipment: Bulk belt conveyor (highlighted in blue) and Site-Specific Equipment: 2_Conveyor (highlighted in yellow). Similarly, for the below highlighted Generic seed equipment: **Generic seed equipment - 1_Box Turner,** the last name **1_Box Turner** (highlighted in yellow) is the Site-Specific Equipment.

Process	Equipment
Raw Seeds Transport	Bulk belt conveyor - 2_Conveyor Bucket elevator - 3_Elevator
Pre-cleaning	Precleaner - 5_Air Seed Cleaner_Separator Pneumatic transfer system - 6_Vacuum Transport System Precleaner - 22_Air Seed Cleaner_Seperator gravity separator - 24_Gravity Table Separator gravity separator - 25_Indent Cylinder Precleaner - 27_Air Column_Precleaner Precleaner - 31_Air Seed Cleaner gravity separator - 33_Gravity Table Separator Sizer - 35_Air Column_Precleaner Generic seed equipment - 1_Box Turner Bulk belt conveyor - 13_Belt Conveyor Sizer - 26_Seperator

Figure 22: Screenshot of Unit considered from EPPD - Nimes [20]

5.3.4.1 Explosion Safety Requirements

Table 21: Observations on Explosion Safety Requirements generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
2.2	Requirements for explosion safety from external sources	Any additional or local explosion safety data manually entered in SpeedExs will appear in this field as a line of text as entered in SpeedExs. **No additional requirements were recorded for the visited sites.**

5.3.4.2 Short plant description

Table 22: Short plant description

EPPD Sub Section	EPPD Sub Section Title	Observation
2.3	Short description of plant/unit	The photographs of the equipment uploaded in the Risk assessment questionnaire (sub-forms) will be displayed in this section. It was not a mandatory field in SpeedExs.

The picture of equipment along with its Site-Specific name was used for displaying the Plant description. The below Figure 23 helps in understanding how the added images in SpeedExs are displayed in the report. Except the equipment photograph, no equipment descriptions were available.

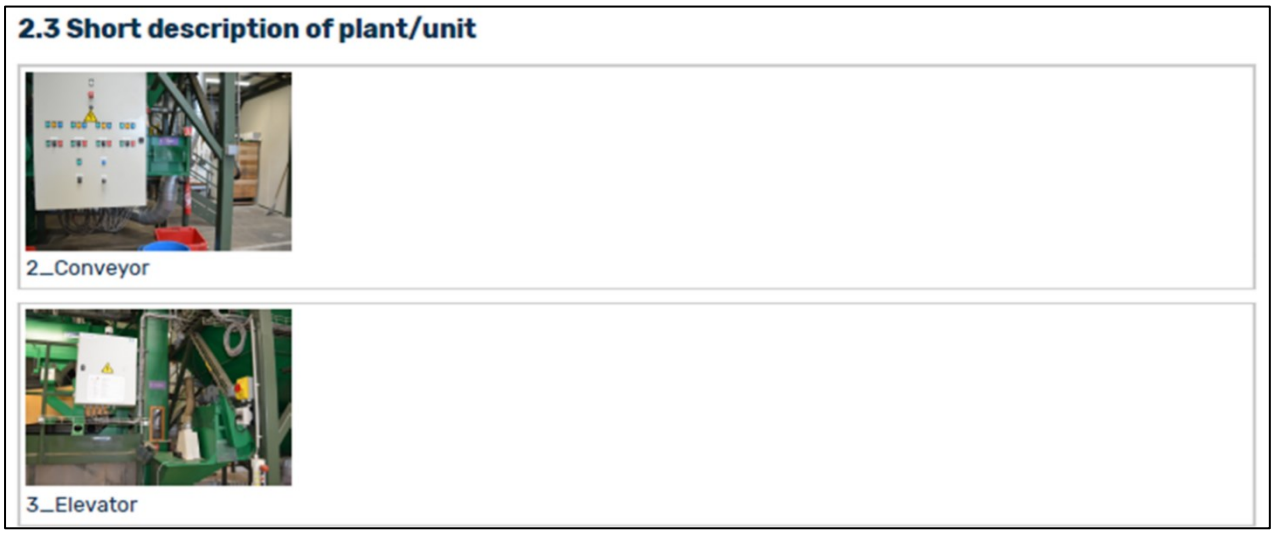


Figure 23: Screenshot of Short plant description from EPPD - Nimes [20]

5.3.4.3 Position and geographical condition

Table 23: Observations on position and geographical condition generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
2.4	Position and geographical condition	The latitudinal and longitudinal position of the site will be displayed under this section. **This information was not displayed for any of the reports.**

5.3.4.4 Ventilation and aspiration details

Table 24: Observations in Ventilation and aspiration details generated in EPPD

EPPD Sub Section	EPPD Sub Section Title	Observation
2.5	Ventilation	A table with Ventilation details for every Room entered in SpeedExs is shown. It also contains the type of Ventilation opted and the Air Exchange rate. Below screenshot Figure 24 is an example from one of the reports.
	Aspiration	Separate tables that are categorised based on the Process and listed with the set of equipment that is associated with that Process, along with data regarding Aspiration and Local extraction for that equipment. Below screenshot Figure 25 is an example from one of the reports.

2.5. Information about Ventilation and Aspiration

Nr.	Room	Location	Ventilation	Air exchange rate	Sensor
1	E 14	Indoor	Technical ventilation	1.00	-
8	Boiler Room for Main Building	Indoor	Natural ventilation	1	No

Figure 24: Screenshot of Ventilation conditions shown in EPPD – Nimes [20]

The below Figure 25 is a screenshot of an example from the site **Bayer – Nimes** EPPD. In the Table, **Filling and Packaging** is a Process, the list under the Process is Equipment.

But the Equipment name mentioned is not the Site-Specific Equipment Name and is either the Pre-defined Equipment Name or Generic Seed Equipment as highlighted in Yellow.

Equipment aspiration /local extraction

Nr.	Raw Seeds Transport	Aspiration / local extraction	Mean velocity [m/s]	Sensor
1	Bulk belt conveyor	Aspiration	18.30	-
2	Bucket elevator	Aspiration	18.50	-

Nr.	Filling and Packaging	Aspiration / local extraction	Mean velocity [m/s]	Sensor
32	Generic seed equipment	Aspiration	10.40	-
33	Generic seed equipment	Aspiration	17.40	-
34	Product Filling Line <100 l	Aspiration	13.70	-

Figure 25: Screenshot of aspiration conditions generated in EPPD [16]

5.3.5 Material safety data

Table 25: Material safety data

EPPD Sub Section	EPPD Sub Section Title	Observation
3	Material data	This section is divided into a table for Flammable gasses / vapour and a table for Combustible Dust substances

This section of the report projects the Safety Data for selected flammable liquids/gases in SpeedExs

As an outcome, the below Figure 26 is an example of screenshot showing the list of properties listed for Flammable gases/vapour.

Table 2: Safety-related parameters of referenced substances of flammable gases/vapours

Substance	Flash point, [°C]	Explosion limits Vol., %	Ignition temperature, [°C]	Temperature class	Explosion group	Comments
Gasoline	< - 35	0.6-8	220 (T3)	T3	IIA	...
Methane	-	4.4-17.0	595	T1	IIA	...
Menno florades	28	3.0-15	>435	T2	IIB	...
Nimrod	40	n.a.	385	T3	IIB	...
Vegetables (generic)	...	...	...	...	...	...
Cotton (Seed, generic)	...	...	...	...	...	...

Figure 26: Screenshot of Safety data for flammable gases/vapours generated in EPPD [22]

Also, as visible in the above screenshot, 'Vegetable' a material that should have been in

Combustible Dust Substances Figure 26 was also getting added in this table for every site in which Vegetable was selected in SpeedExs. Additionally, Cotton (Seed, generic) was also appearing in the table, when all the seed units in the General Site details which are Corn, Canola, Rice, Vegetable, Soyabean, Grain, Cotton were selected in SpeedExs as part of trail test.

For correction, this has been brought to IT's attention.

For the combustible dust, the below screenshot Figure 27 projects the list of properties considered for the selected substances in SpeedExs.

It has been found that in SpeedExs, selecting the seed unit in General Site Details window would automatically capture the flammable dust data for the seed selected. In other words, when selecting Corn and Canola as the type of seed under General Site information, the details for Corn (generic) and Canola (generic) will be displayed, as seen in the Figure 27 displaying the screenshot below.

Table 3: Safety-related parameters of combustible dusts

Substance	Combustion number	Dust explosion capability	Lower explosion limit [g/m3]	MIT [C]	MIE [mJ]	Median [µm]	Glowing temperature [°C]	Reference
Corn (generic)	4-2	ST1	30-60	...	10	...	...	NFPA 652/ NFPA 61, FSA (Radant)
Canola (generic)	4	1	60-75	...	30-Oct	12	...	NFPA 61, canola dust 2016, GESTIS DUST-EX

Figure 27: Screenshot of safety data for combustible dusts generated in EPPD [22]

5.3.6 Explosion Protection Concept

A brief description about hazard classification based on various zones for both flammable liquid/gases and combustible dusts referring to various regulations are described in this sub section. **This remains common for all the site reports.**

5.3.6.1 Hazardous area classification and Measures

Table 26: Hazardous area classification and measures

EPPD Sub Section	EPPD Sub Section Title	Observation
4.1	Hazardous area classification and technical measures (ignition source control/protection)	The zones identified for each equipment in SpeedExs will be complied and projected under this sub section. The technical measures like ignition source control and explosion protection for the equipment are identified.

Figure 28 a screenshot from the report is a perfect example depicting various scenarios generated in this sub section which are:

1. Based on each Process the hazardous area classification and the respective measures to control the explosion risk are indicated.
2. In Figure 28 Pre-cleaning is the Process, Plant Operation is Room, 6_Vacuum Transport System is the Equipment. Here in the screenshot below, the Box Turner is an equipment that was added to SpeedExs using Generic Seed Equipment, while the remaining equipment are predefined.
3. Under 'Hazardous area classification', the determined zones are listed below the corresponding Equipment. Also, under ‘Measures to control the explosion risk’, the specific equipment's technical measures are specified.
4. Including the scenarios mentioned in the below point number 5, all the equipment for which Zones are identified will have the Measures to control the explosion risk.
5. Even though No Zone was created for the site-specific equipment - 13_Belt Conveyor, the report included the Measures to control the explosion risk. Also, same is the case for any Generic Seed Equipment. Measures to control explosion risk will be generated even though No Zones were identified if No aspiration line is opted in the respective Risk assessment questionnaire.
6. The Technical Recommendations entered in SpeedExs (Refer in 5.2.3.4.Adding assessment Recommendations) will be generated here in the report.

- **Pre-cleaning**

  Hazardous area classification:

  - Plant Operation
    - 6_Vacuum Transport System:
      - Zone 22: inside equipment
      - No zone: outside equipment
    - 22_Air Seed Cleaner_Seperator:
      - No zone: inside equipment
      - No zone: outside equipment
    - 24_Gravity Table Separator:
      - No zone: inside equipment
      - No zone: outside equipment
    - 1_Box Turner:
      - Zone 22: inside equipment
      - No zone: outside equipment
    - 13_Belt Conveyor:
      - No zone: inside equipment
      - No zone: outside equipment

  Measures to control explosion risk:

  - Plant Operation
    - 6_Vacuum Transport System:
      - Ex-rated electrical equipment inside equipment
      - Grounding and bonding for all conductive (metallic) parts
      - Ex-proof mechanical equipment required inside equipment
    - 1_Box Turner:
      - Ex-rated electrical equipment inside equipment
      - Grounding and bonding for all conductive (metallic) parts
      - Avoidance of hot surfaces
      - Ex-proof mechanical equipment required inside equipment
    - 13_Belt Conveyor:
      - Dust extraction
      - Belt cleaners required

Figure 28: Screenshot of different scenarios in generating measures in EPPD [20]

5.3.6.2 Administrative measures for Explosion prevention

Table 27: Administrative Measures generated in EPPD

EPPD Sub Section	EPPD Sub Section Title		Observation
4.2	Administrative measures with respect to explosion prevention	4.2.1. Work Permit	The administrative measures with respect to explosion prevention such as work permit, change management, information for contractors and information on regular maintenance and inspection is explained under this subsection referring other internal documents wherever applicable.
		4.2.2. Change Management	
		4.2.3. Integration of third-party companies	
		4.2.4 Regular maintenance and Inspection	
4.3	General requirements		A generic statement stating that the General requirements for infrastructure, like fire protection, lightning protection or other (earthquake, flooding) are assessed in other documents is made.

This section EPPD as mentioned above remains same across all the reports generated.

The administration measures entered in the SpeedExs as explained in sub-chapter 5.2.3.4.Adding assessment Recommendations appears under the section 4.2 in EPPD.

No additional administrative measures were added in SpeedExs during the assessment across the 20 sites.

5.3.7 Action Items

A list of pre-defined Action items is generated for the equipment for which Measures to control explosion risk were identified. Action item contains a pre-defined list of checklists, generated based on identified Zones.

Action items are generated for each Pre-defined equipment based on the answers given in risk assessment. Also, in case of Generic Seed equipment, irrespective of the site-specific equipment, a pre-defined checklist based on selected zones will be generated as Action item.

The Action Items generated in this report was be addressed and verified with the help of Site HSE

and Maintenance focal and if any of the action item is not fulfilled, they were marked and submitted to the site in a separate checklist titled "Mandatory Action Items" for implementation. This will be discussed further in the upcoming sub chapter 5.3.8.3 Annex C.

Out of 20 site assessments conducted, for 17 sites the Action Items have been completed successfully.

Below is the list of sites for which Action Items were not completed.

Table 28: Reason for Action items not completed

S. No	Site Name	Reason
1	Wageningen	Due to time limitation in verifying and completing the action times during the site visit.
2	Szatymaz	FORM was working on updating the software and the software was not accessible to generate the report during the time of assessment.
3	Mustafakemalpasha	The complexity of the site resulted in a time constraint in verifying and completing the Action items.

Some of the action item questions were modified/updated during the site tour by reaching out to Admin. Following Table 29 explains the amended questionnaires in action items.

Table 29: Amended questionnaires in action items

S. No	Equipment name	Predefined action item checklist	Modified action item checklist
1	Boiler Burner	Is there any local regulation for gas detector in boiler/ burner room? If so, are gas detector installed in proper position according to local regulations.?	Is there any local regulation for gas detector in boiler/ burner room? If there is local regulation in boiler/ burner room, are gas detectors installed in proper position according to these local regulations?
2	Gasoline Station	a) Is the air intake protected from ingress of metal parts & particles? b) Is the product feed intake protected against ingress of metal parts? c) If any non-electrical power-driven equipment (e.g., rotary valve) is installed inside: Is it ex-proof and suitable for the respective zone?	Deleted from checklist
3	Safety Cabinet	a) Is the ex-proof equipment checked regularly about its ex-proof properties? (Interval: Minimum 03 Years) b) Is the non-electrical equipment outside of the safety cabinet ex-proof and suitable for the defined zone? c) Is the ex-proof equipment checked regularly about its ex-proof properties?	a) **Rephrased question:** Is the ex-proof electrical equipment checked regularly? b) Is the non-electrical equipment outside of the safety cabinet ex-proof and suitable for the defined zone? c) **Rephrased question:** Is the ex-proof non-electrical equipment checked regularly for its ex-proof properties?

In the early stage of the assessment, the equipment for which a checklist was not necessary, the heading of the equipment without any checklist was generated in the EPPD. In the below Figure 29 showing the screenshot, for the highlighted equipment in blue, only headings were generated.

Checklist for equipment 3_Elevator

Checklist for equipment 5_Air Seed Cleaner_Separator

Checklist for equipment 6_Vacuum Transport System

6_Vacuum Transport System	Status			Action
	yes	no	n/a	
Are housekeeping procedures available & applied on site?				
Does housekeeping result in complete avoidance of dust layers outside of equipment?				

Figure 29: Screenshot of Initial action item checklist in EPPD – Nimes [20]

Later after escalating this with IT and as suggested by them, this was modified and was generated with informative information as seen in the below Figure 30.

Checklist for equipment Diesel Tank_R&D Lion

Diesel Tank_R&D Lion	Status			Action
	yes	no	n/a	
only informativ: no specific measures required for outside this equipment, as "no zone" defined outside this equipment.				
only informativ: no specific measures required for inside of this equipment, as "no zone" defined inside this equipment.				

Figure 30: Screen shot of modified action item checklist [22]

5.3.8 Appendices

In the subsequent subchapters, results from Annex A, Annex B, Annex C, Annex D which form the appendices, are described.

5.3.8.1 Annex A

Table 30: Observations on Annex A

EPPD Sub Section	EPPD Sub Section Title	Observation
Annex A	Working with combustible dusts (informativ)	This sub-section contains general information on how to work safely with combustible dusts and the steps that needs to be taken for machines that handle flammable liquids or dusts. In addition, it includes details on the various ignition sources that are common for the seed industries. **This remains common for all the reports generated.**

5.3.8.2 Annex B

Table 31: Annex B

EPPD Sub Section	EPPD Sub Section Title	Observation
Annex B	General checklist to control implementation	A checklist covering questionnaires on hazard and explosion identification, training and inhouse instruction, management of change, installation testing subjected to explosion hazards, competency of employees. Total 31 questions which are pre-defined and are generated in every EPPD report. Out of 20 assessments for 17 sites the Annex B was completed.

5.3.8.3 Annex C

Table 32: Annex C

EPPD Sub Section	EPPD Sub Section Title	Observation
Annex C	Mandatory action items	• Annex C contains the Mandatory action items which are mandatorily to be implemented by the site. (Also discussed in 5.3.7 Action Items)545.3.7. • A time period of six months is given to implement these recommendations. • Mandatory action items are compiled and the page is added in EPPD using pdf editor Adobe Pro DC.

As part of the risk assessment process, a comprehensive list of mandatory action items will be created, combining the evaluation of unfulfilled Action items and general safety deviations observed during site visits. The identified Mandatory action items were then given for implementation to the respective sites. In accordance with common industrial practice, it is the assessor's responsibility to provide the mandatory action item checklist to the site.

As an assessor for the visited sites except for **Bayer – Mustafakemalpasha**, I was responsible for providing the necessary mandatory action items to the respective site.

Following the required approval from an explosion safety expert, the final Explosion Protection and Prevention Document (EPPD) will be presented to the relevant site, along with the mandatory action item checklist, for implementation. A list of the specific sites that were issued with these Mandatory action items is provided in the sub-chapter 5.1 Status of the Assessment.

In order to provide the reader with an example of how Mandatory action items look like, a screenshot of the Mandatory action items for Bayer-Nimes is displayed in Figure 31.

Annex C: Mandatory Action Items

S No.	Room/Area	Equipment	Action to be implemented	Priority	Comments	Responsible person
1	-	General Recommendation	Check the grounding for all the electrical equipment where ever necessary. Make sure the grounding resistence is in the required range. And, maintain the grounding records whenever checked.	Normal		Site Management
2	Boiler Room	Gas Boiler_Old	Tightness of the piping system must be checked during the preventive maintenance of the boiler.	High		Site Management

Figure 31: Screenshot of mandatory action items from EPPD – Nimes [20]

5.3.8.4 Annex D

When 'yes' option is selected for the question "**Display collected data of equipment**" as mentioned in point number 7 of sub - section 5.2.1 General Site Details the details like Manufacturer Name, Series Number, Risk assessment questions the selected answers of the respective equipment added in SpeedExs are displayed in Annex D of the EPPD report. This option was not initially available and was later added in SpeedExs and therefore not utilised for the generated reports.

5.4 Regulatory compliance data

5.4.1 Identifications from EN 1127

Table 33: Identifications from EN 1127

S. No	Requirements from EN 1127 – 1		In comparison with SpeedExs
	Section	**Brief description**	
1	Hazard identification - Combustion properties	The following are examples of combustion properties for hazard identification. 1) flash point. (For flammable liquids/gases) 2) explosion limits. 3) limiting oxygen concentration.	• Only flash point and explosion limits are identified for flammable gases/liquids. • Limiting oxygen concentration is not applicable due to absence of intertization in seed sites. • Not identified for combustible dusts.
2	Hazard identification - Ignition requirements	The following properties are examples of ignition requirements for hazard identification. 1) minimum ignition energy. 2) ignition temperature of an explosive atmosphere. 3) minimum ignition temperature of a dust layer. (For combustible dusts)	• Only minimum ignition energy and minimum ignition temperature of a dust layer is available for combustible dusts. • Not identified for flammable gases/liquids. • Dust safety data can be displayed in report only for the dusts that are predefined in SpeedExs. If more data is required then the data has to be added by admin.

S. No	Requirements from EN 1127 – 1		In comparison with SpeedExs
	Section	**Brief description**	
3	Hazard identification - Explosion behaviour	The following properties are to be identified for combustible dusts/flammables. 1) maximum explosion pressure (pmax). 2) maximum rate of explosion pressure rise ((dp/dt) max). 3) maximum experimental safe gap (MESG). (For flammable liquids/gases)	Not identified for both flammable gases/liquids and combustible dusts.
4	Risk assessment includes the following elements	Hazard identification using safety data sheet.	Hazard is not identified based on the safety data. (Refer "Assigning a Site-specific equipment in SpeedExs" serial number 2, under section 6.3.3 Discussion on Risk Assessment for discussion)
		Determining the amount and likelihood of an occurrence of an explosive atmosphere.	Zone classification identified in EPPD based on the user's input.
		Determining the presence of effective ignition sources.	Identified in EPPD
		Estimating the possible effects of an explosion.	Not identified.
		Risk reduction.	Identified in EPPD, under the heading - Measures to control explosion risk.

S. No	Requirements from EN 1127 – 1		In comparison with SpeedExs
	Section	Brief description	
5	Classification of hazardous areas	Zoning classification for gases/vapor (Zone 0, Zone 1, Zone 2). Zoning classification for dust (Zone 20, Zone 21, Zone 22).	Identified in EPPD.

5.4.2 Identifications from ATEX derivative 1999/92/EC

Table 34: Identifications from ATEX derivative 1999/92/EC

S. No	Requirements from ATEX derivative 1999/92/EC		In comparison with SpeedExs
	Section	Brief description	
1	Assessment of explosion risks	1) The likelihood that an explosive atmosphere will occur. 2) The likelihood that sources of ignition will be present and become effective.	Zone classification identified in EPPD based on the user's input.
2	Technical measures for explosion protection	Explosion protection measures means all measures that: 1) Prevent the formation of hazardous explosive atmospheres. 2) Avoid the ignition of hazardous explosive atmospheres 3) Mitigate the effects of explosions so as to ensure the health and safety of workers.	Identified in EPPD.
		Zoning the hazardous area and avoid the ignition sources.	Identified. In EPPD.

S. No	Requirements from ATEX derivative 1999/92/EC		In comparison with SpeedExs
	Section	**Brief description**	
		Mitigation of the effects of explosions (mitigation measures) 1) Explosion resistant equipment. 2) Explosion relief. 3) Explosion suppression. 4) Prevention of explosion propagation.	Identified in EPPD.
		Application of process control engineering	
3	Organizational measures for explosion protection	1) Operating instructions. 2) Worker competence. 3) Training of workers. 4) Worker supervision. 5) Permit to work system. 6) Maintenance. 7) Inspection and checking. 8) Marking of hazardous places.	Identified in EPPD under general checklists.
4	Explosion protection document - Requirements under Directive 1999/92/EC	That the explosion risks have been determined and assessed.	Identified in EPPD.
		That adequate measures will be taken to attain the aims of the directive.	
		Those places which have been classified into zones.	
		That the workplace and work equipment, including warning devices, are designed, operated and maintained with due regard for safety.	

S. No	Requirements from ATEX derivative 1999/92/EC		In comparison with SpeedExs
	Section	**Brief description**	
5	Implementation of Explosion Protection Document	The document must be 1) tailored to conditions in the firm concerned. 2) well-structured and easy to read 3) the degree of detail should allow a general grasp of its content. 4) no excessive documentation	Partially covered and not satisfactory. (Refer sub section 6.4.2 Discussion on Scope of application point number 1 for discussion on this point)
6	Specimen layout for an explosion protection document	Description of the workplace and working areas.	Not identified.
		Description of the process steps and/or activities.	Partly identified and not satisfactory. (Refer sub section 6.4.3 Discussion on Plant information for discussion)
		Description of the substances used/safety parameters.	Partly identified and not satisfactory. (Refer "Assigning a Site-specific equipment in SpeedExs" serial number 2, under section 6.3.3 Discussion on Risk Assessment for discussion)
		Results of the risk analysis.	Identified in EPPD.
		Explosion protection measures taken.	Identified in EPPD.
		Implementation of the explosion protection measures.	Identified in EPPD. (Refer sub section 6.3.1 Discussion on General Site Details in SpeedExs point number 6 for discussion on this point)

5.4.3 Identifications from ISO/IEC 60079-10-2

Table 35: Identifications from ISO/IEC 60079-10-2

S. No	Requirements from ISO/IEC 60079-10-2		In comparison with SpeedExs
	Section	**Brief description**	
1	Area classification procedure for explosive dust atmospheres	1) Determine the material characteristics. 2) Identifying the area where the dust atmosphere can occur. 3) Determine the likelihood of the explosive dust atmosphere.	Partly identified and not satisfactory. (Refer "Assigning a Site-specific equipment in SpeedExs" serial number 2, under section 6.3.3 Discussion on Risk Assessment for discussion)
2	Competence of personnel	Area classification has to done by the person who are familiar with knowledge and the characteristics of dust, process and equipment.	Identified in EPPD.
3	Sources of release	It is necessary to determine the source of the released dust since it is not certain that all dust sources would generate an explosive environment under all circumstances.	Identified in EPPD.
4	Zones	The extent of a zone for explosive dust atmospheres is identified here. It is the distance in any direction from the edge of a source of dust release to the point where the hazard associated with that zone is considered to no longer exist.	Identified in EPPD.
5	Avoiding dust layer formation	By housekeeping.	Identified in EPPD.

6 Discussion

6.1 Quantification of time for current working methodology

An attempt to quantify the average time taken to perform risk assessment using SpeedExs in the current way of working is shown in the below Table 36. After considering the variations in different sites and various configuration of equipment complexities, the calculation has been made considering a Medium site of 100 equipment, out of which 20 complex machineries like Boiler, dust filter, etc., and 80 regular machineries are considered (See Step 2, Step 3 and Step 4 in Table 36). This division of equipment is based on the experience from sites visited and has been done in order to get more accurate values for the calculation.

The following example is intended to help understand the calculation involved in Step 2.

Let's say that there are 80 complex equipment and 20 simple equipment that need to be analysed in Step 2.

For a single complex equipment, it takes approximately 5 minutes to complete Step 2 in order to thoroughly understand its working principle, and for a single simple equipment with a straightforward working principle, it takes only 3 minutes.

So, for 20 complex equipment, the total time required to complete Step 2 would be:

20 equipment x 5 minutes per equipment = 100 minutes

Similarly, for 80 simple equipment, the total time required to complete Step 2 would be:

80 equipment x 3 minutes per equipment = 240 minutes

To calculate the total time required for all 100 equipment, we add the time required for complex equipment and simple equipment:

100 minutes + 240 minutes = 340 minutes

To convert this to hours, we divide by 60:

340 minutes / 60 = 5.67 hours

Therefore, the total time required to complete Step 2 for all 100 equipment would be approximately 5.67 hours.

This same methodology is applied to each step to ensure accuracy.

Table 36: Calculation for current way of working

S. No	Step Number	Activity	Number of Equipment	Time taken for each activity per Equipment (in minutes)	Time consumed for 100 Equipment (in hours)
1	Step 1	Equipment details from site and assigning the details in SpeedExs using a laptop with Windows OS	100	-	16
2	Step 2	Field tour + Analysing the site + Noting down findings + Capturing high resolution photos	20	5	5.67
			80	3	
3	Step 3	Completing field tour and carrying out SpeedExs risk assessment in laptop	20	5	8.33
			80	5	
4	Step 4	EPPD report generation (01) for Action item checklist + Completing Action item checklist	20	15	15.67
			80	8	
5	Step 5	Converting the captured images up to 200KB and uploading in SpeedExs	100	5	8.33
6	Step 6	EPPD report generation (02) from SpeedExs (One time task for all the equipment)	-	10	0.17
7	Step 7	Editing the Action item in the EPPD report generated + adding Annex C (Mandatory Action Item) using Adobe Pro DC (pdf editor)	100	5	8
8	Step 8	Publishing the final EPPD report	-	-	-
Total man hours					**62.17**
Total number of days considering 8-hour shift per day					**7.8**

As per the calculations it takes around approximately **62.17 hours** or **7.8 working days** for a Medium site. This method of calculation was found convincing as it matches with the time consumed based on the real time scenario for a Medium site.

6.2 Discussion on status of assessment

For **Bayer – Sinesti**, a complex site, was performed using SpeedExs only for a particular area within the site. The decision to limit the scope of the assessment was motivated by the site's urgent need for risk management in terms of explosion safety in relation to a specific process. Therefore, the assessment was focused exclusively on that process, and a set of Mandatory action items was provided to the site using SpeedExs. These recommendations were formulated

based on the recommendations provided by SpeedExs along with some additional recommendations on general safety gaps observed during the site visit, and were intended to enable the site to make the necessary modifications to their practices to effectively mitigate those risks.

I was responsible to aid and collaborate with an external contractor in performing a risk assessment using SpeedExs at **Bayer – Mustafakemalpasha**. However, due to time constraints, the action item checklists generated by SpeedExs were not fully completed. The findings of the assessment, as well as the resulting EPPD report, were incorporated into this thesis.

The remaining uncompleted actions in the Table 3 are due to the time constraint and software update in case of assessment in **Bayer – Szatymaz**.

6.3 Discussion on SpeedExs

6.3.1 Discussion on General Site Details in SpeedExs

This sub-section discusses results from sub-chapter 5.2.1 General Site Details

1 **Point number 1 in results**: As observed, it was the correct decision to have the assessor choose the site location in SpeedExs from a list of options created by the Admin. This is due to the possibility that different users will have different naming philosophies, which could result in many entries with the same name details over time.

2 **Point number 4 in results:** As per the results this field was not utilised due to the lack of readily available data. This field can be used for entering other regulatory requirements, area classification document, certification from regulatory bodies to operate Hazardous equipment like LPG tanks, Boiler etc. and will be listed in sub heading 2.2. Requirements for Explosion safety in the generated EPPD report

3 **Point number 5 in results:** Only 5 sites had the equipment list in a proper format and this caused delay in gathering this information for feeding in SpeedExs. As mentioned in point number his was the reason why the field **Upload equipment list** was not utilised. Though it is not a part of the final report (EPPD), having a complete equipment list will ease the assessor in choosing the equipment related to explosion safety rather than selecting the equipment during the field tour.

4 **Point number 6 in results:** The list of additional findings that were gathered from the site tour were uploaded but it was noticed that the data is not a part of EPPD. However, this uploaded document can be downloaded anytime from server which can be utilised by the assessor to know the previously uploaded findings. Since the sites cannot access this server an additional section at the end of the EPPD was created called Mandatory Action Items for the site to confirm and take actions. These Mandatory Action items the requirements help the site to comply with ATEX Directive 1999/92/EC.

5 **Point number 7 in results:** The ISO/IEC 60079-10-2, the sub section - Area classification document: states that the reason for the decision taken to establish the type and extent of zones and extent of dust layers should be mentioned [15]. In EPPD this statement is fulfilled by utilising the field mentioned. During a trial test it was found that in EPPD, a separate 'Annex D' was generated containing a table with the list of equipment and corresponding risk assessment question and selected answers as shown in Figure 32 appears.

ANNEX D

No.	Question Label	Question Answer
	2_Conveyor	
1	*What kind of material is handled with the Belt conveyor?	Coarse material with low fines content
2	*Is a dust aspiration installed at the conveyor?	Yes
3	*Is the conveyor closed by a cover or open?	Cover, dust can accumulate (completly closed cover).
4	*Is the area around the equipment always free of dust layers?	Yes, the area is clean.

Figure 32: Screenshot of Annex D in EPPD [22]

6.3.2 Discussion on Plant Structure Classification

This sub-section discusses results from sub-chapters available in 5.2.2 Plant Structure.

1 The use of both Process and Room was relevant for small and medium sites, while proceeding with the same methodology of tagging both Process and Room for complex site was not viable because the complex sites had minimum of 250 equipment and utilizing both of these classifications led to multiple groupings making the Plant structure in the report complex. So, it was decided to have the complex site plant structure only with Room and respective equipment.

2 As seen in the result 5.2.2.2, Technical ventilation field i.e., air exchanges per hour has been given with value 1.00. When Technical ventilation was selected, it is mandatory to enter some number into the field and the sites did not have the data for the Technical ventilation. Since it was a number only field, dummy value of 1.00 was provided, in order to proceed with the assessment. These values are not used by the software for risk assessment or auto generation of the zones. But knowing these values will help the user to understand whether the Room has an adequate ventilation or not. It was found that most of the sites didn't have the data or facility to measure it.

6.3.3 Discussion on Risk Assessment

Following points are the discussions from the section 5.2.3.1 Assigning Equipment

1 As stated in the result 5.2.3.1. Assigning Equipment, a Pre-defined equipment was utilized for multiple site-specific equipment because of the same working principle of both the equipment. For example, from the Gravity separator (Pre-defined equipment) was used for the Indent cylinder (Site-specific equipment). The indent cylinder does a basic separation of the seeds which is also done by the Gravity separator. These operations are understood with the help of site personnel during the site tour. Likewise, all the equipment listed in the same table had the same operating principle which led to the utilization of the pre-defined equipment for a site-specific equipment. And this philosophy was verified by comparing the zones generated in SpeedExs with the actual scenarios.

2 The Table 10 contains equipment like Seed Treater/Seed Blender, Belt conveyor, Intake pit, Static Dryer and Dust Filter which are available as pre-defined equipment in SpeedExs. They were still classified under Generic Seed equipment because the zones generated in SpeedExs were found inappropriate in compared to the site-scenarios. This detail is collectively captured in Table 14: Changes in equipment configurations and Table 15 under sub section 5.2.3.3.1 Amendment in equipment risk assessment questionnaires. In order to include this equipment temporarily in SpeedExs, the Generic Seed equipment was used.

   The other equipment like Sealer for Vegetables, Seed Counter, Potting Machine, Big Bale Breaker, Dibbling Machine, Compactor, Husker and Sorting Table were the actual Generic Seed equipment for which zone identification was not required but still required to be a part of EPPD.

Following points are discussion on findings from section 5.2.3.1.3 Assigning a Site-specific equipment in SpeedExs

1 **Point number 5 in results:** The findings in this point indicate that while selecting the availability of an aspiration or local extraction line in Equipment, it is mandatory to enter aspiration and local extraction values. However, with the exception of the **Bayer-NIMES** location, the other sites lacked the data or facility to measure these values. As a mandatory numeric field, a dummy value of 1.00 was provided to proceed with the assessment. The software does not directly use these values for risk assessment or auto-generation of zones. However, it does inquire separately about the availability of aspiration in the risk assessment questionnaire, and the aspiration requirement for the equipment is also displayed as part of the questionnaire. Without access to actual site data, it is challenging to determine if the aspiration provided is sufficient. Knowledge of these values can assist the user in understanding whether the equipment has adequate aspiration to remove hazardous atmospheres.

   On observing these aspiration related results in EPPD, the projected the Table 24 showing equipment aspiration and local extraction details has the equipment name as pre-defined or generic seed equipment name rather than site specific name. Figure 25 containing the screenshot describing two different equipment with the same title as generic seed equipment explains this point.

   This is possibly an implementation error in EPPD. Also, this kind of description will confuse the site personnel as they are familiar with only the site-specific equipment name.

2 **Point number 6 in results:** Capturing Safety data of flammable materials in EPPD is a requirement from regulations. (Refer Chapter 5.4 Regulatory compliance data)

   The list of flammable data mentioned in – in line. 1, 3 and 4 list flammable data that are handled in smaller quantities at sites, which do not require separate risk assessments. However, these flammables are stored and handled in safety cabinets, which are considered equipment in SpeedExs. All sites have safety data sheets for the flammables handled in safety cabinets and other locations to meet safety data maintenance requirements. Regulations mandate that the lists of flammables utilised by site must be included as part of the EPPD.

   Also, in the same table the flammable data mentioned line 2, 5 and 6 are flammable liquids handled in tanks and cylinders. These range from a storage capacity of 5 litres in cylinders to more than 2000 litres in bullets and are not considered in Pre-defined equipment. In order to continue the assessment, and temporarily assign this equipment in SpeedExs,

the option of Generic Seed equipment was tried. But Generic Seed Equipment doesn't have the option to classify flammable gases/vapour Zones (Zone 0, Zone 1, Zone 2) and only combustible dust Zones. Similar is the scenario with the list of equipment that needs to be added in SpeedExs as mentioned in Table 16 serial number 1, 2, 3 and 4 for which risk assessment was not carried out for the equipment because of the lack of Pre-defined equipment in SpeedExs. Instead, general recommendations were given in Annex C – Mandatory Action Items of the EPPD report. The equipment in the serial number 5, 6, 7 were implemented as Pre-defined equipment in SpeedExs.

3 **Point number 7 in results:** In case of dust data as observed in Results, the dust data provided in SpeedExs is not user friendly and lacked the guidance for the user in choosing the appropriate dust data. Also, most of sites didn't had the dust data and it is required to undergo a dust analysis study in each site which in return will give us the list of dust and its properties This data will help the assessor in understanding the various dusts produced in the sites and help in answering the common risk assessment questionnaire like mentioned in the Table 37: below.

Table 37: Risk assessment questionnaire and options related to dusts

S. No	Risk assessment questionnaire	Available options
1	What kind of seed is loaded into this equipment?	Fine products with high amount of fine dust
		Coarse material containing low amount of fine contents
		Coarse material with no fine dust content
2	Solid concentration < 10 g/m³ in gas stream?	Yes/No

The above questions were answered analysing the dust visually or assuming worst case scenario in order to complete the assessment.

As observed in result in **point number 4**, only **Bayer – Bergschenhoek** had the safety data for dust. In order to collect very fine sand particles from various equipment, the site had implemented a dust filter. As a result of dust data analysis carried out by the site, it was determined that the particles were not combustible. This allowed me to conclude that there was no zone present within the equipment, thanks to the availability of the relevant safety data. However, SpeedExs still generated a zone within the dust filter. (Refer Table 10 serial number 12 showing this data)

The above discussion highlights the importance of having safety data available for materials handled in seed sites. In order to avoid these situations, it is important for any site handling dust to be aware of the potential hazards associated with it and having knowledge of the composition of the dust. It is concerning that many of the sites lack data on the dust they handle. This may indicate a lack of awareness of the importance of this information, or a lack of resources or training to obtain and interpret such data.

Even though the selection of safety data of flammable liquids/gases and combustible dust is not mandatory and doesn't impact the software's Zone generation, in the absence of the safety data of flammable liquids/gases and combustible dusts an assessor will consider the equipment operating in worst case scenario and this will cause generation of zones in SpeedExs even in area where no hazard exists.

Following are the worst-case scenarios considered for zone identification in SpeedExs:

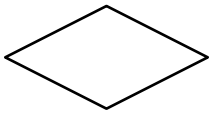
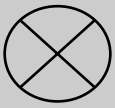
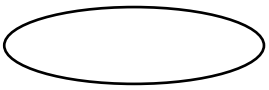
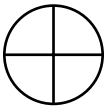
a) In the absence of safety data of flammable liquids/gases and combustible dusts, always a possibility of fine dust appearing in an equipment which handles components that can generate dust is considered.

b) When the rate of air exchange in technical ventilation and velocity of air in aspiration and local extraction lines are unknown, the equipment is assumed to have natural ventilation, and no aspiration is selected in risk assessment questionnaire after cross-checking with the real time conditions of the equipment.

6.3.3.1 Discussion on Risk Assessment Process Flow

This algorithm of the SpeedExs Software can be described using a Process Flow Diagram, and for the purpose of understanding the algorithm's background operation, a Process Flow Diagram for three equipment will be discussed in the upcoming pages. The below Table 38 shows the list of symbols utilized in the Process Flow Diagram

Table 38: Legend for the process flow diagram

Symbol	Description
	Process flow direction
	Decision
	Split junction for parallel activity
	Start / End
	Branching nodes
	Or junction

6.3.3.1.1 Equipment – Cyclone Separator

In the process flow shown in Figure 33 with the questionaries identifying the Cyclone Separator's process condition and its surrounding which led to the Zone identification is projected.

The parallel steps involved in zone identification of the equipment's internal and external sections are also shown in the diagram. Zoning occurs concurrently for the internal and external areas, as shown by the 'Split junction for parallel activities' symbol.

Possible zones identifications in the different locations of the equipment are given in the below table.

Table 39: Zoning possibilities for Cyclone

S. No	Area	Possible zones
1	Cyclone (Inside)	Zone 20, Zone 22
2	FIBC (Inside)	Zone 21
3	Rotary valve (Inside)	Zone 21
4	Outside equipment	No Zone, Zone 22, Zone 22 - 1m around the point of dust release

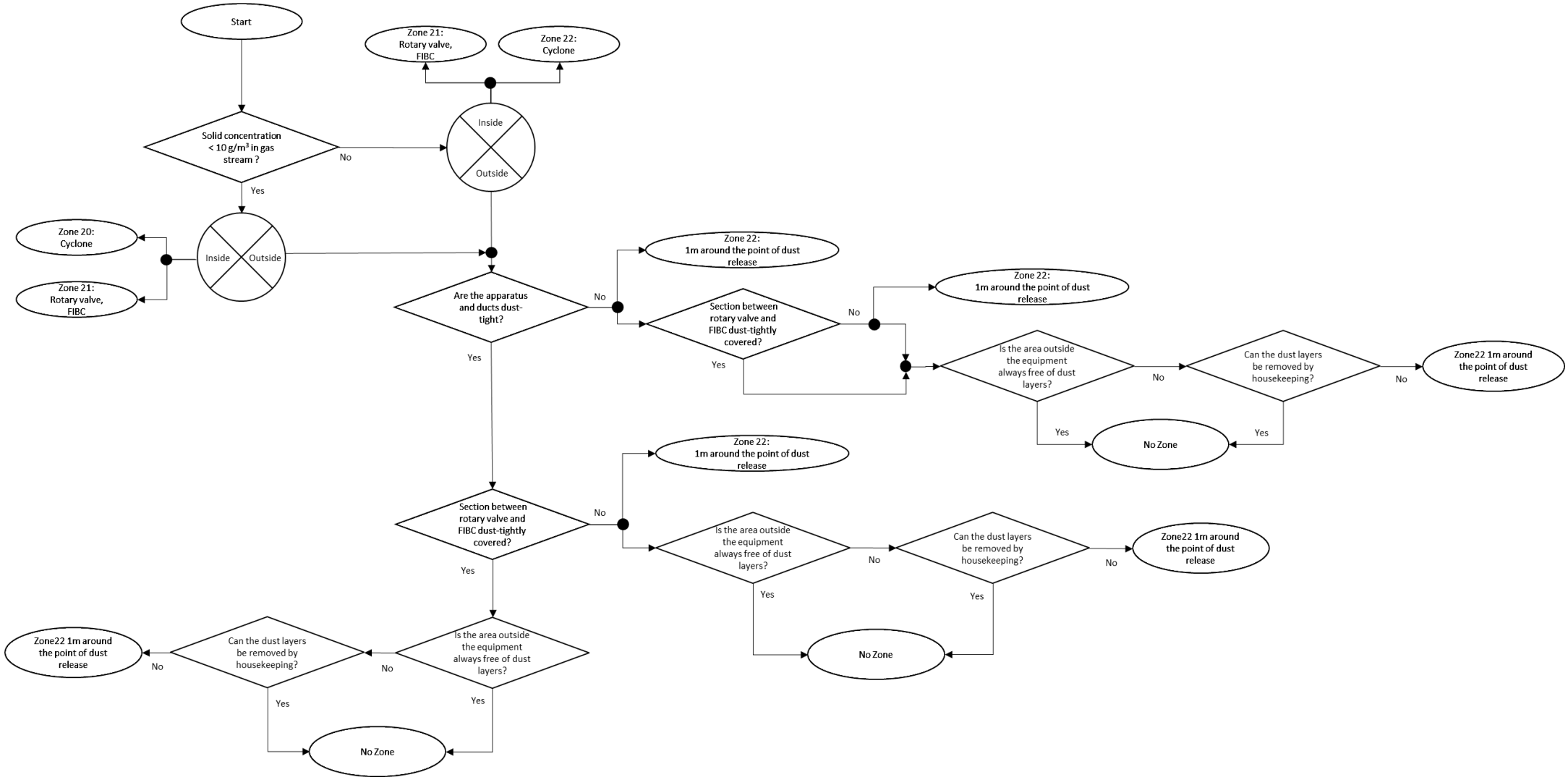


Figure 33: Process flow for zoning Cyclone

6.3.3.1.2 Equipment – Sheller

For Sheller Figure 34 describes the Process flow for zone identified in Inside equipment and zone identified outside equipment.

Here, one may see that the equipment is zoned according to the type of dust, the presence of an aspiration system for the equipment, and the presence of dust layers within the equipment.

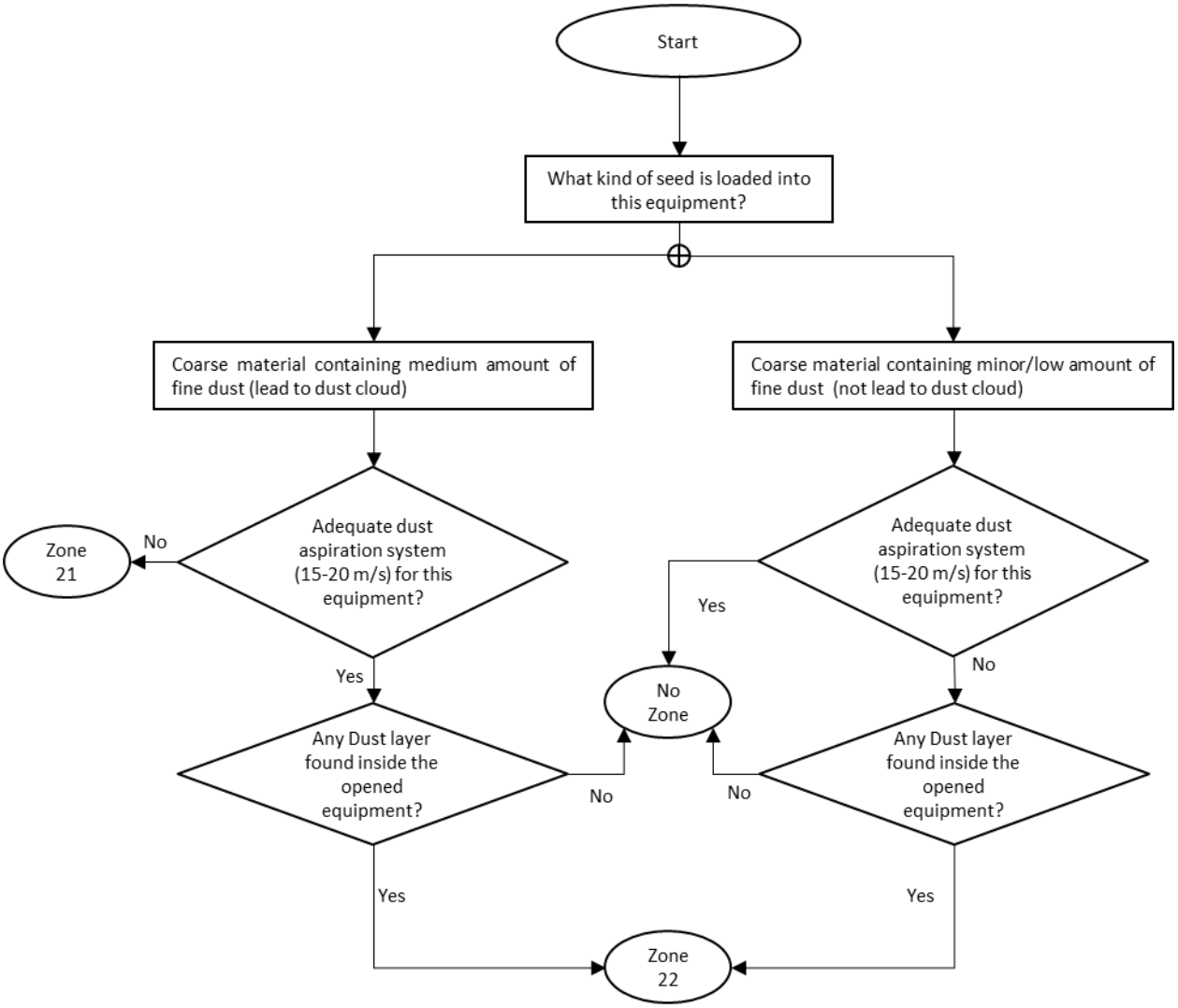
The zone for the outside of the equipment is determined once the questions for the inside zoning have been answered.

Possible zones identifications for inside and outside of Sheller are given in the below Table 40

Table 40: Zoning possibilities for Sheller

S. No	Area	Possible zones
1	Sheller (Inside)	Zone 20, Zone 21, Zone 22
2	Outside equipment	No Zone, Zone 22

i. Zone identification for Inside of Equipment



ii. Zone identification for Outside of Equipment

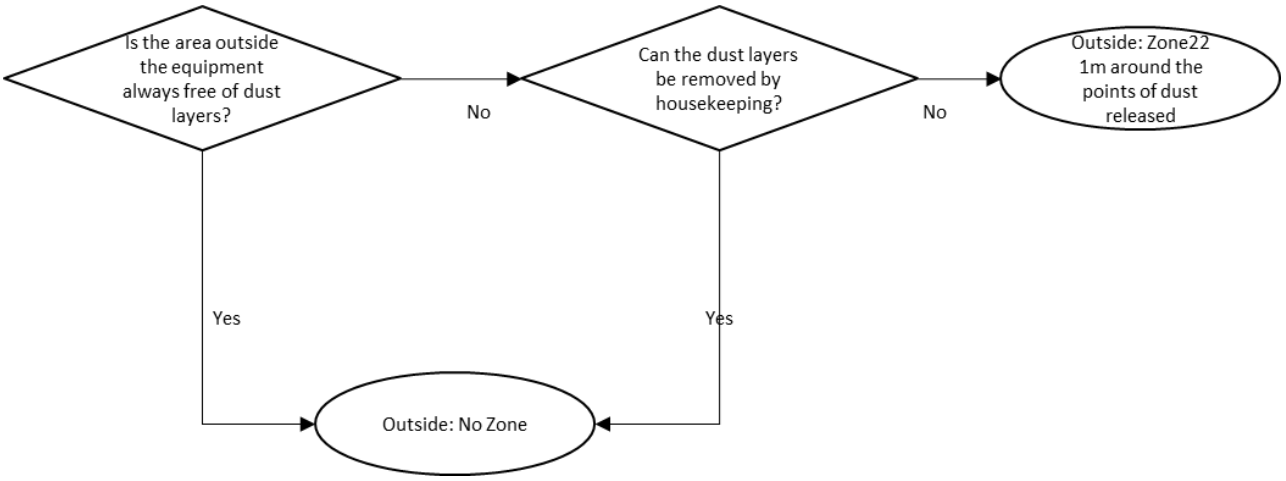


Figure 34: Process flow for zoning inside and outside the Sheller

The discussed Process flows will give an idea to the reader that, each Pre-defined equipment will have its own Workflow derived from Pre-defined risk assessment algorithm document.

6.3.3.1.3 Generic Seed equipment

Below Figure 35 shows the process flow describing the Risk assessment questionnaire for any Generic Seed equipment.

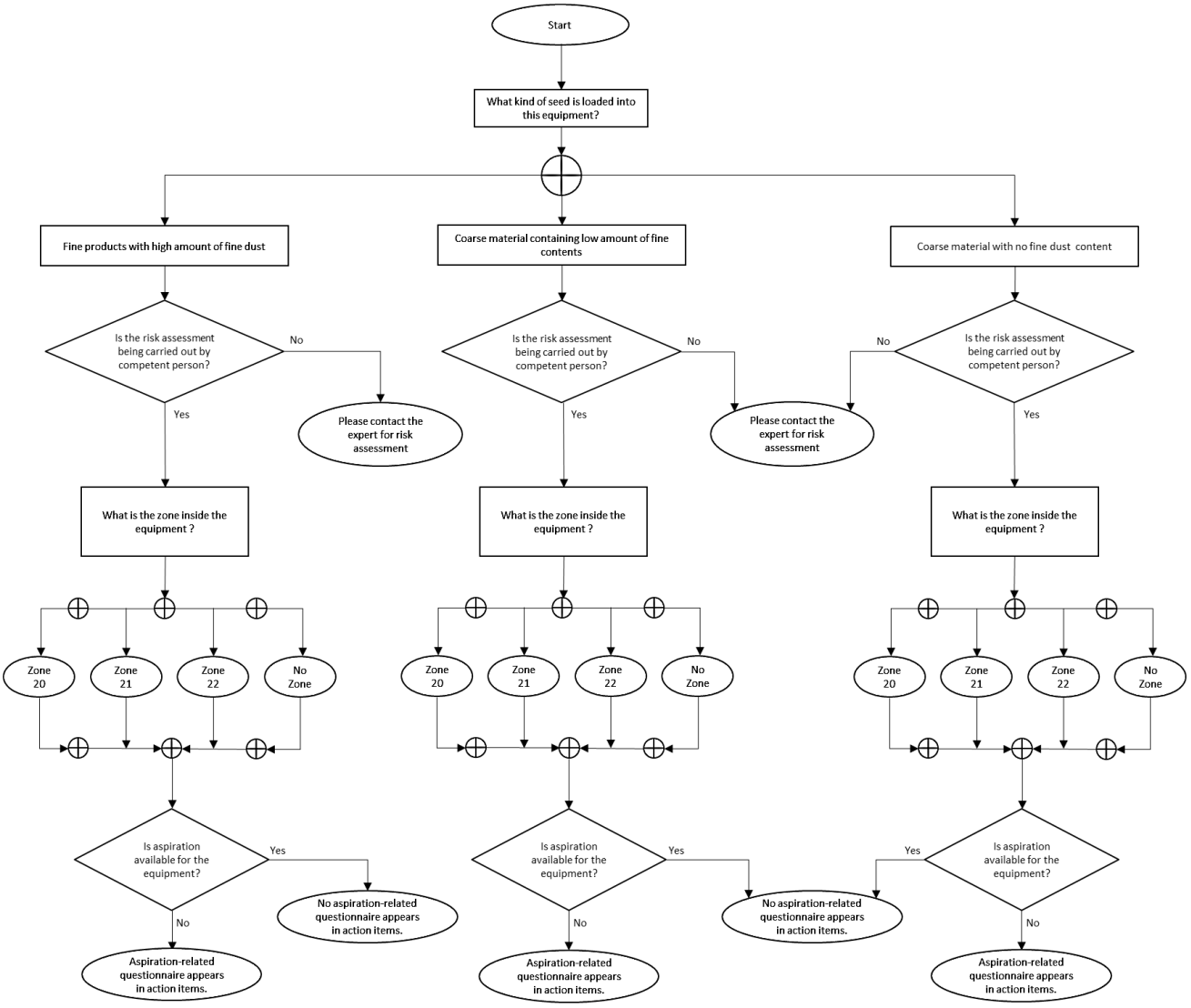


Figure 35: Process flow for zoning in Generic Seed Equipment

For Generic Seed equipment the Zone identification and Risk Assessment is manually entered.

6.3.3.2 Discussion on Pre-defined equipment

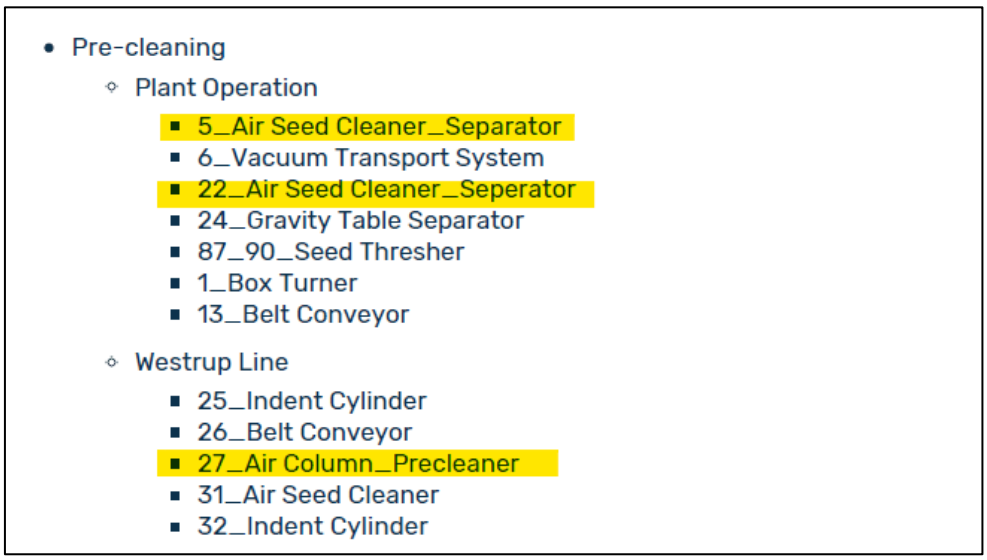


Figure 36: Screenshot of Pre-defined equipment in EPPD [19]

In the above Figure 36 the highlighted yellow mark indicates the Site-specific equipment which has been customized by using a Pre-defined equipment. i.e., the Pre-defined equipment 'Pre cleaner' is assigned to both 'Air Seed Cleaner' and 'Air Column'. This also means that the Risk assessment questionnaire of the Pre-defined equipment 'Pre cleaner' is applicable to the respective site equipment too.

6.3.3.3 Discussion on Equipment description

The equipment description as discussed in 5.2.3.2. Equipment description and uploading pictures, will appear in the initial section of the Risk Assessment questionnaire. This is very informative during the time of assessment as it describes the detailed functionality of the equipment helping the assessor to understand the equipment and its priority. For the equipment have multiple sub-components, the sub-configuration of that equipment is also described which helps the assessor to verify with the site equipment configuration.

6.3.3.4 Discussion on Amendment in equipment risk assessment questionnaires

This sub section explains the reasons behind amendment in risk assessment questionnaire after carrying out the site assessment mentioned in.

1 While carrying out assessment for safety cabinet in **Bayer – Wageningen**, a question stated that all the vessels kept in the safety cabinet should be sealed and should not have been opened before. This was contrary to the safety cabinet's intended usage because it also

needs to be used to store used vessels, which must be kept tightly closed

2 In case of Bin, in **Bayer – Sinesti**, the site has this equipment dedicated to fill the dust, from the outlet of dust filter and also from various other dust collection points. Since the dust is being transferred into the Bin continuously, there will always be a cloud of dust inside the Bin leading to Zone 20 inside it. Initially, the risk assessment questionnaires were leading to Zone 22 instead of Zone 20. This was corrected by altering the algorithm by adding more options that included different types of time and its retention time.

6.3.3.5 Discussion on Change in Equipment configuration and Zone identification

1 A Pre-defined equipment used in multiple sites is having a common set of equipment, configurations i.e., as mentioned in table 16 under the column Pre-defined equipment configuration the equipment Seed Treater has the configuration of Seed hopper + Scale chamber + Treater + Additives hopper + Rotary valve. But while carrying out assessment in Bayer - Mustafakemalpasha the Seed Treater configuration only had Seed hopper + Treater + Additives hopper + Rotary valve. The rest of the equipment configuration was also being shown in SpeedExs as well as in EPPD report including their respective zones. i.e., SpeedExs as well as EPPD reports are having equipment components with zone identifications which are physically not present in site. The similar problems in equipment configuration were identified and listed in the Table 14.

2 However, in the equipment mentioned in Table 15 the site conditions were such that the equipment had no zone is present in it. But because this equipment was Pre-defined, the SpeedExs was generating zones. This could have been corrected in SpeedExs by adding additional option for a key question in risk assessment questionnaire i.e., in considering the equipment Belt Conveyor mentioned in the Table 15 questions can be modified as shown in the following table.

Table 41: Recommended modifications in risk assessment questionnaire

S. No	Questions Asked	Current Options Available	Required modifications in options
1	What kind of seed is loaded into this equipment?	Fine products with high amount of fine dust	Fine products with high amount of fine dust
			Coarse material containing low amount of fine contents-
		Coarse material containing low amount of fine contents-	Material with no dust content

Choosing the last option “Material with no dust content” should be defined in the algorithm as no zone. This is the same case with the rest of the equipment as mentioned in the table.

6.4 Discussion on EPPD

6.4.1 Discussion on EPPD Cover Page

1 In the cover page of the EPPD, the address mentioned is the asset code and the location of the site. Bayer being a multi-national company, the possibility of multiple asset/plant in same location are more. In such scenario, the address mentioned in the cover page will lead to confusion and it would be better to have the complete site address.

2 As the document is the proof of the audit/assessment, the name and date of assessment would be a mandatory field for future references as well as other audit purpose. Considering this, the Regional account also should have the name of the author and the date of the assessment. In case of SSO user account, the author’s name is being projected correctly, only the date of assessment needs to be addressed all of these can be seen in Figure 17. Similar issue related to the name of the Author is found in Summary as well, which can be seen in the Figure 18. Date of creation as seen in the Figure 17 is the date and time whenever the report is generated. Since the report is generated multiple times for different activities lasting over a week before the final report is published. This will change the date of creation of the report and will not match with the date of assessment.

6.4.2 Discussion on Scope of application

1 As per the 1999/92 ATEX Derivative mentioned under Results in point number 5, the EPPD for a site must be presented in a format that is easy to understand. However, when examining the EPPD report, it is observed that the section on "**1.2 Scope of Application**" and the section on "**2.1 Units considered**" contain redundant information. The former section lists equipment classified based on both process and room (as shown in Figure 20), while the latter section only classifies equipment based on process (as shown in Figure 22). This repetition of information can consume a significant part of the EPPD report, especially in the case of a complex site.

In addition, it was mentioned in the introductory paragraph of section 5.3 EPPD, that the document is exclusively created in English. However, a few sites requested the EPPD to be provided in their local language during the site request. This raise concerns, as Bayer sites are located worldwide, and it is possible that not all employees may understand the EPPD in the language used.

2 As observed in the findings **Bayer – Mustafakemalpasha,** under 5.3.3.2 Scope of application, the report generated contained the classification based on Room first and then the corresponding Process was shown for every equipment (Refer Figure 21). This shouldn't have been the case since, irrespective of the priority in selection of Process or Room first, the sequence of appearance in the report should have been Process followed by Room and Equipment.

The IT team suggested later that whenever Process is selected for a Task and the report is generated, the Process are stored in the server and cannot be deleted. Though it can be deselected from the software, the changes will not be reflected in the report. Therefore, it was suggested to delete and re-enter the whole Plant Structure and Equipment. This functionality was not identified before.

Due to time constraints and the completion of the Risk assessment, it was difficult to delete and re-enter the equipment data for this complicated site containing around 250 equipment from SpeedExs. Consequently, IT has been tasked with finding a solution.

6.4.3 Discussion on Plant information

In plant information as mentioned in the Table 20 the definition of responsibilities defined in EPPD is vaguely stating that the operator of the site is represented by plant manager and other functions with their respective areas of responsibilities. It will be necessary to record the responsibilities of key focal in a RACI chart (Responsible, Accountable, Consulted and Informed) or the sake of future reference, audit purpose in the event of any mishaps, and taking into account EPPD as the

only track for documenting the history of assessment.

According to the 1999/92 ATEX Derivative mentioned under Results in point number 6, the specimen layout of the Explosion Prevention and Protection Document (EPPD) should include a description of both the workplace and working areas, as well as the process steps and/or activities involved. However, in the generated EPPD's, the description of the workplace and working areas is presented only through photographs uploaded in SpeedExs with a title, lacking a comprehensive textual description. Similarly, for the process steps or activities, the EPPD only lists the name of the process step, as mentioned in 5.3.4.2 Short plant description, but does not provide any further detail or description of the site's activities or workplace.

6.4.4 Discussion on Action items

As observed in the Table 29 following were the reasons for the amending the questionnaires of Action item checklists.

1 Boiler Burner: Due to the fact that there were two questions in a single question, it was divided for better comprehension.

2 Gasoline Station: The mentioned previous action item points did not to the Gasoline station. Therefore, it was removed from the checklist.

3 Safety cabinet: Initial questions were improper and caused confusion. Therefore, properly rephrased.

6.5 Software performance

The following observations were identified in the performance of the software.

1 The software was compatible with laptops, mobile phones, and tablets with Windows and iOS operating systems.

2 In Tasks of **Bayer - Nimes and Wageningen**, while uploading high-resolution images of equipment into SpeedExs, the software repeatedly crashed. When the issue was brought to the attention of the IT team, they suggested using images up to 200 KBs. Tasks for Nimes 2 and Wageningen 2 were created again, and the entire Process, Room, and Equipment list was re-added respectively with low-resolution images.

3 As more sites were added to the Task, the performance of SpeedExs decreased, and it took an average of 20 minutes to synchronise the data into the server, during which time no other tasks could be performed.

4 The software frequently encountered errors during synchronisation, as depicted in Figure 37 below. If the synchronisation issue occurs, the cache data from the memory were erased,

causing the software to log out of the SSO and log back in before being synchronised again which will consume an average of additional 20 minutes.

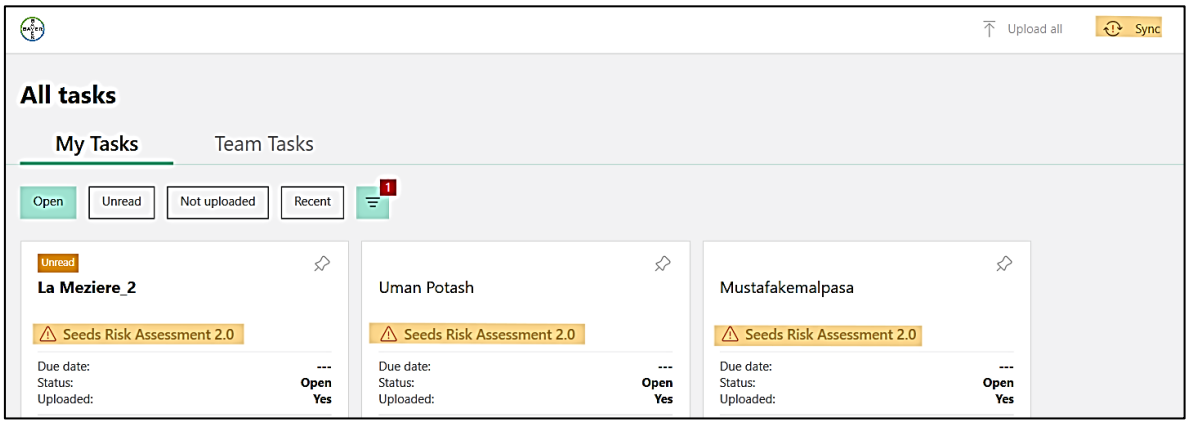


Figure 37: Screenshot showing synchronisation issue in SpeedExs [18]

5 For **Bayer - Mustafakemalpasha**, the Regional user account was used to create the Task and conduct the risk assessment. During the synchronisation issue and the practice of deleting the cache data led to the loss of complete data in the Task. The issue was brought to the attention of the IT team, who are currently determining a solution.

6 In iOS operated tablet, the programme demonstrated much improved speed. This was determined after taking into account both the synchronisation time and the loading time for each page. When used in Windows, the synchronisation process for the software took an average of 20 minutes, but it took only 3 minutes when run in an iOS environment.

7 Some random software glitches were noted during the assessment:

a) The below screenshot is from EPPD generated for **Bayer – Nimes**. Zone identification was found missing in the report. Only the measures to control explosion risk appeared in the report.

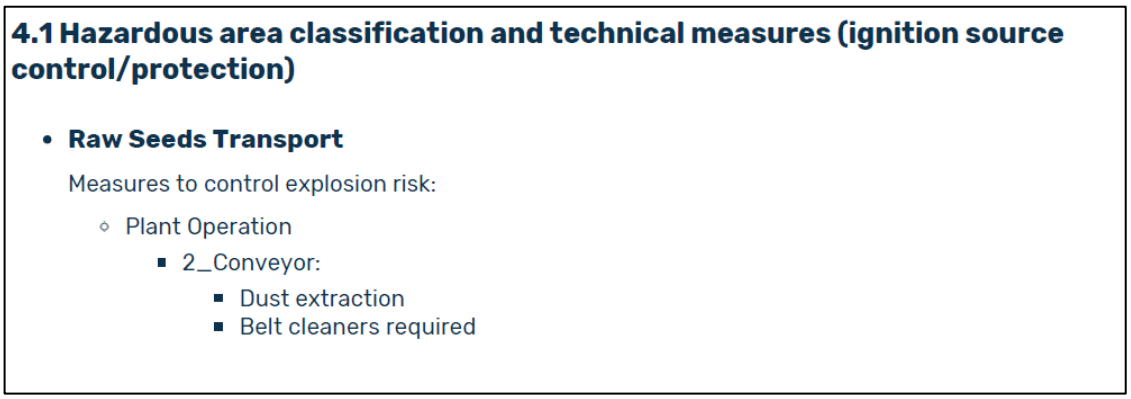


Figure 38: Software glitch -1 [20]

b) Below checklist is from the **Bayer – Olmeneta**. Two different checklists are generated for the same zones (inside and outside) of the Pre-defined equipment questionnaire as shown in the Figure 39. The yellow highlighted area shows the information which is generated for the Seed Treater_1 but missing in Seed Treater_2.

Checklist for equipment Seed Treater_1

Seed Treater_1
Metal parts of equipments must be securely grounded.
Inspection of grounding before start-up, after maintenance and on a regular basis. Maintenance according to producer's requirements.
Protection against intake of foreign metallic objects (e.g. loosened bolts)
Secure clearance between moving and static parts
Equipment and PCT suitable for zone, explosion group and max. surface temperature for dust or temperature class for liquid, vapors, gases, mists respectively
Inspection and maintenance of electric equipment/ PCT according maintenance plan aligned to vendor's requirements
Are procedure (SOP) / Prevention Maintenance plan in place to check for tightness of piping system: e.g. leakage test for flexible hose connection
only informativ: no specific measures required for outside this equipment, as "no zone" defined outside this equipment.
Is there a aspiration at each filling and discharge point?
Does the dust extraction result in a min. flow rate of 1.25 m/s in the free space of the filling and discharge pont?
Is the aspiration monitored (flow sensor) with interlock of conveyor on low flow?
Is monitoring checked once per year?

Checklist for equipment Seed Treater_2

Seed Treater_2
Metal parts of equipments must be securely grounded.
Inspection of grounding before start-up, after maintenance and on a regular basis. Maintenance according to producer's requirements.
Protection against intake of foreign metallic objects (e.g. loosened bolts)
Secure clearance between moving and static parts
Equipment and PCT suitable for zone, explosion group and max. surface temperature for dust or temperature class for liquid, vapors, gases, mists respectively
Inspection and maintenance of electric equipment/ PCT according maintenance plan aligned to vendor's requirements
Are procedure (SOP) / Prevention Maintenance plan in place to check for tightness of piping system: e.g. leakage test for flexible hose connection
Is there a aspiration at each filling and discharge point?
Does the dust extraction result in a min. flow rate of 1.25 m/s in the free space of the filling and discharge pont?
Is the aspiration monitored (flow sensor) with interlock of conveyor on low flow?
Is monitoring checked once per year?

Figure 39: Software glitch -2 [23]

c) The image of the dust filter that was uploaded in SpeedExs did not appear in the report that was generated for **Bayer-Olmeneta**. The image did not reflect even after saving and synchronising the software.

7 Recommendation

1 Date of Assessment:

As addressed in discussion 6.4.1 Discussion on EPPD Cover Page the Date of Creation and Date of Assessment are not same. Therefore, auto generated date will not work for this kind of working process. A, manual entry of Date of Assessment is recommended to be an option in SpeedExs. This manual entry of Date of Assessment can be placed at the end of risk assessment in SpeedExs.

2 Distribution List:

In order to identify the recipients of EPPD, it is recommended to have a data field in SpeedExs where the name, email ids and position of the personnel are mentioned which will be generated in the cover page of EPPD. Through this one can track the recipients of EPPD.

3 Regulations for Explosion safety:

As observed in 5.3.4.1 Explosion Safety Requirements, instead of "2.2 Requirements for explosion safety from external sources" appearing as text, it is suggested to be captured in SpeedExs as well as in EPPD in a tabular form as shown below for better understanding and tracking of these external regulations.

Table 42: Sample format for displaying regulations for explosion safety

S. No	Document Name/Regulation for explosion safety	Version	Location of the document in site

4 Ventilation and Aspiration:

As per the discussion regarding ventilation and aspiration/local extraction fields, since they not have any connection with zone generation, it is suggested to be enabled with a provision to enter alpha numeric value so that the user can provide that the technical ventilation is not measured which can auto generate an administrative recommendation to measure the technical ventilation. Alternative recommendation is to link the ventilation and aspiration fields data with the risk assessment questionnaire which will be a contributing factor for zone identification rather than the assessor deciding if the value is adequate or not.

5 **Pre-defined equipment addition:**

It is recommended to add the following equipment to be added into SpeedExs as mentioned in Table 16.

i. Chemical/Flammable handling area

ii. Pressurised gas cylinders

iii. Bullet tanks

iv. Box Turner

6 **Generic Equipment:**

Based on the discussion in sub section 6.3.3 Discussion on Risk Assessment," serial number 2 of "Assigning a Site-specific equipment in SpeedExs", about the Generic Seed equipment not having zone identification for flammable liquids and vapours (Zone 0, Zone 1 and Zone 2), it is recommended to rename the Generic Seed equipment as Generic equipment in SpeedExs and give additional options to choose Zones for flammable liquids and vapours. Even though the equipment involving flammable liquids and gases are recommended in the previous point to be added to SpeedExs as Pre-defined, additionally the option to consider any equipment as Generic rather than just Generic Seed equipment should still be available.

7 **Modification in Equipment Risk Assessment Questionnaire:**

According to the discussion in section 6.3.3 Discussion on Risk Assessment," under serial number 2 of "Assigning Equipment" it is recommended that the risk assessment questionnaire for equipment such as the Belt Conveyor, Intake Pit, Static Dryer, and Dust Filter should be revised to incorporate a scenario where an explosive atmosphere is not present. This modification would enable a more comprehensive evaluation of potential risks associated with the equipment, including hazards that may arise in different operating conditions.

8 **Equipment Configuration:**

Based on the discussion 6.3.3.5 Discussion on Change in Equipment configuration and Zone identification considering the issue mentioned in point number 1, it is advised to give options in SpeedExs to select and unselect the sub-components of the equipment. Based on the site requirement the accessor can opt for the equipment configuration required.

9 **Equipment Description:**

As per the discussions in 6.3.3.3 Discussion on Equipment description it is recommended to have the equipment description for all the equipment in SpeedExs. Also, for few equipment,

the equipment configuration details mentioned in equipment description of SpeedExs helped in comparing with the site equipment configuration. Therefore, it is recommended to mention the equipment configuration & description for the rest of the equipment wherever applicable.

10 Structuring EPPD and Language requirement:

To avoid the issue discussed in 6.4.2 Discussion on Scope of application point number 2, it is suggested that the "**1.2 Scope of Application**" section be classified based only on room, as rooms are used across all Bayer sites, regardless of size or complexity, and represent individual site areas. An overview of the site classified based on room is sufficient, and there is no need to define the scope of application based on a list of equipment.

Furthermore, considering that Bayer sites are located globally, it is possible that not all employees may be able to comprehend the EPPD in the language used. Therefore, it is recommended that the final EPPD report be available in the local language to ensure that all employees can understand its content. This is particularly important for ensuring the effective implementation of dust control measures and prevention of combustible dust explosions, which can have severe consequences for worker safety and plant operations

11 Prioritizing Mandatory Action Items:

The EPPD reports generated using SpeedExs includes a statement indicating that the listed action items should be completed within six months (As seen in the summary shown in Figure 18) As shown in Figure 31, during the course of the assessments, I provided the sites with a list of mandatory action items based on priority. However, in addition to prioritization, it would be beneficial and recommended to detail the time required for completing each action item according to the Bayer standard. This additional information could assist the site in better managing their resources and prioritizing action items accordingly.

12 Integrating Safety Data into Risk Assessment Algorithm:

Given the discussions outlined in sections 6.3.3 Discussion on Risk Assessment under “Assigning Equipment” regarding the safety data of combustible dust, flammable liquids, and gases, it is suggested that the safety data be integrated into the risk assessment algorithm. By inputting the relevant properties of combustible dust and flammable liquids/gases, the algorithm can determine the likelihood of an explosive atmosphere. This integration would address the significant variability in the application of SpeedExs and result in a standardized report, reducing dependence on the assessor's expertise in identifying the properties of combustible dust/flammable liquids and gases. This approach would be beneficial as it would improve the consistency and reliability of the risk assessment process.

Furthermore, it is recommended to provide the users with information that will help them to

select the appropriate dust data This will also enable them to make informed decisions regarding the selection of Pre-defined equipment.

To address this issue in a simple and efficient manner, it is highly recommended to optimize the dust data available in SpeedExs. By optimizing the existing data, it may be possible to improve the quality of information available to users without requiring significant additional resources or effort.

13 Recommendation to Prevent Overwriting of Data in Regional User Account Task:

As per discussion in point number 5 of 6.5 Software performance, following recommendation is made in order to avoid the issues of overwriting the data in Task available in the Regional user account. If a User is already logged into the Regional user account and another user wants to access the same Task, a message saying "This Task is already being utilised by another user" should appear.

14 Recommendation for capturing assessment history in EPPD reports:

The only way to capture the assessment history is a detailed EPPD report and not the SpeedExs software as it doesn't capture the history of its assessments and only can keep the recent assessments in its memory. So, the below recommendations are required to be generated in EPPD report to track history.

a) Author and Date of assessment on the cover page of EPPD report as discussed in 6.4.1 Discussion on EPPD Cover Page.

b) RACI chart defining the plant management

c) Annex C as suggested in recommendation number 11, containing the mandatory action item listed in a proper format with the action item priority and closure details must be maintained.

d) Annex D should be made mandatory. The table should also mention the Zones generated to the corresponding equipment. Annex D not only fulfils the ATEX requirement, but captures the assessment questionnaires and options selected at the time of assessment, which will become a boon for future references and for further audit purpose.

15 Modified working methodology for improvised way of working:

Figure 14 described the current working scenario for risk assessment using SpeedExs and it is evident that current way of working is a tedious and inefficient.

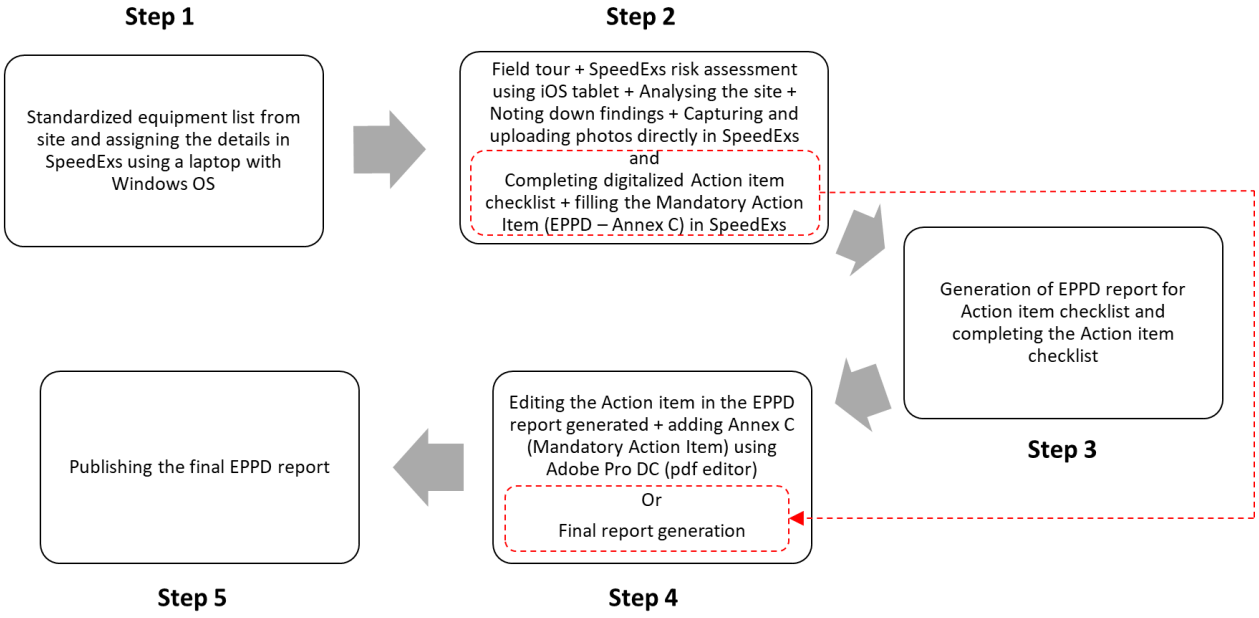
The below modification in the system will help in executing these tasks in a best possible way.

1 The discussion in section 6.3.1 Discussion on General Site Details in SpeedExs serial number 3, revealed that most of the assessed sites lacked an equipment list. To streamline the assessment process and reduce the pre-work time, it is suggested to standardize the equipment list across all sites which includes collecting data like equipment configuration details, ventilation and aspiration, dust analysis study and flammables data. This would allow the assessor to understand the site's requirements and communicate any missing Pre-defined equipment, safety data in SpeedExs, giving enough time for the Expert team to add it. Also, it would be a one-time effort to maintain a standardized equipment list and can be updated when necessary. (Sample equipment list for standardising is shown in Annex A)

2 Using iOS tablet for risk assessment while in field for improved performance. (Refer 6.5 Software performance)

3 Integrating Action item checklist in SpeedExs and using iOS tablet.

Based on the above suggestions, the existing system can be improvised in two different ways.



*** The Red dotted box indicates the process flow when all three modifications are implemented.**

Figure 40: Suggested workflow for risk assessment

a) By implementing point 1 and 2 from the modifications suggested:

This is an easy modification as the changes involve standardising the Equipment list from the site and using iOS tablet for risk assessment. As shown in, Figure 40 the total Steps involved will be reduced to five steps in compared to the current way of working with eight steps as shown in Figure 14. Also, when same calculation methodology is applied as mentioned in Chapter 6.1, considering a Medium site of 100 equipment, then the calculations for the various steps will be as shown in the below table.

Table 43: Calculation for improvised way of working

S. No	Step Number	Activity	Number of Equipment	Time taken for each activity per Equipment (in minutes)	Time consumed for 100 Equipment (in hours)
1	Step 1	Standardized equipment list from site and assigning the details in SpeedExs using a laptop with Windows OS	100	-	8
2	Step 2	Field tour + SpeedExs risk assessment using iOS tablet + Analysing the site + Noting down findings + Capturing and uploading photos directly in SpeedExs	20	20	17.33
			80	8	
3	Step 3	Generation of EPPD report for Action item checklist and completing the Action item checklist	20	15	15.66
			80	8	
4	Step 4	Editing the Action item in the EPPD report generated + adding Annex C (Mandatory Action Item) using Adobe Pro DC (pdf editor)	100	15	8
5	Step 5	Publishing the final EPPD report	-	5	-
Total man hours					**48.99**
Total number of days considering 8-hour shift per day					**6.1**

b) By implementing all the three modifications:

When implementing the three modifications suggested as shown in Figure 40 will save a lot of time as shown in below Table 44.

Table 44: Calculation for digitalised way of working

S. No	Step Number	Activity	Number of Equipment	Time taken for each activity per Equipment (in minutes)	Time consumed for 100 Equipment (in hours)
1	Step 1	Standardized equipment list from site and assigning the details in SpeedExs using a laptop with Windows OS	100	-	8
2	Step 2	Field tour + SpeedExs risk assessment using iOS tablet + Analysing the site + Noting down findings + Capturing and uploading photos directly in SpeedExs and Completing digitalized the Action item checklist + digitalized the Mandatory Action Item (EPPD – Annex C) in SpeedExs	20	25	28.33
			80	15	
3	Step 3	This step is excluded			-
4	Step 4	Final report generation	100	15	-
5	Step 5	Publishing the final EPPD report	-	5	-
Total man hours					**36.33**
Total number of days considering 8-hour shift per day					**4.5**

Following table is provided as a summary of all the working methodologies.

Table 45: Summary of working methodologies

S. No	Working methodology	Total man hours	No. of working days
1	Current way of assessing Risk Assessment using SpeedExs	62.17	7.8
2	a) By implementing point 1 and 2 from the modifications suggested:	48.99	6.1
3	b) By implementing all the three modifications:	36.33	4.5

16 Annex C in EPPD report:

Annex C is not a part of Table of Contents generated by the EPPD as of now (Refer 5.3.8.3 Annex C). Since many of the Mandatory action items are a result of unfulfilled Action item checklist, digitalising the whole process as mentioned in the above recommendation number 15 can resolve this issue. Or other option is to link the SpeedExs uploaded file to EPPD report in such a way that the uploaded file will be generated as “Annex C” in EPPD report.

8 Summary

This master thesis evaluates the SpeedExs software used for risk assessment in Bayer's seed processing industry and identifies areas for improvement. The study examines the results generated by SpeedExs and recommends modifications to enhance the efficiency of the risk assessment process. While the software can reduce human error and standardize the approach, it needs customizations to fully utilize data and address bugs.

The current methodology for risk assessment is found to be inefficient, leading to recommended modifications such as standardizing the equipment list, using an iOS tablet, and integrating an action item checklist in SpeedExs. The study also identifies the major risk in carrying out the risk assessment process as the assessor's competency. While Bayer's explosion safety expert team had considered various scenarios for occurrence of hazardous zones eliminating the risk to a maximum extent, addition of more Pre-defined equipment in SpeedExs and detailed risk assessment questionnaires related to nature of dust are necessary.

The study found the SpeedExs software to be efficient in data input and collection, but it lacked data utilization in places such as ventilation, aspiration, and safety data for substances. It is important to note that any digital tool is only as effective as the quality of the data and analysis it is based on. The accuracy and relevance of the risk assessments generated by SpeedExs will depend on the quality of the input data and the expertise of the users conducting the analysis. Therefore, it is essential that users of the software are well-trained and knowledgeable in

The thesis also provides insights into the gaps in the generated EPPD report, with a focus on the cover page, scope of application, and action item sections, providing recommendations where necessary.

The study concludes that adapting the SpeedExs software to utilize recorded data, address bugs, and incorporate more predefined equipment will enhance the reliability of the zones generated by SpeedExs as a part of risk assessment process. The development of SpeedExs software is a positive step towards strengthening safety procedures in the seed industry, aiding in identifying and mitigating potential hazards, preventing accidents, and ensuring the safety of employees and the environment.

9 Outlook

The conclusions drawn from this thesis indicate several possible directions for future research and development in the field of risk assessment using SpeedExs and safety procedures followed in the seed processing industry. One crucial area of focus is the need to enhance the versatility and comprehensiveness of the SpeedExs software by integrating additional Pre-defined equipment. Further analysis concentrating on identifying such equipment and scenarios could enhance the accuracy and reliability of risk assessments.

Another area that requires further investigation is the enhancement of risk assessment questionnaires related to dust, which could be made more elaborate and include various scenarios, even those where an explosive atmosphere is absent. The thesis also found that the SpeedExs software lacked the use of recorded data in areas such as ventilation value, aspiration value, and safety data for materials. FORM could concentrate on incorporating these data utilization aspects to improve the efficiency and accuracy of the risk assessment process.

In addition, this thesis underscores the significance of well-trained and knowledgeable individuals conducting the analysis to ensure the precision and relevance of the risk assessments generated by the software. Therefore, the explosion safety expert team could focus on developing training programs to equip software users with the necessary skills and knowledge in risk assessment and safety procedures.

Overall, these potential areas for future development and progress provide a foundation for improving and strengthening the process of risk assessment using SpeedExs in the seed industry. By addressing the identified areas for improvement, Bayer can enhance the efficiency and accuracy of the risk assessment process, thereby ensuring the safety of employees and the environment.

10 Annex A

An equipment list, considering the requirement of SpeedExs, is shown in Figure 41: Sample equipment list to standardise across all sites. as a sample for sites to utilize.

S.No	Process	Location/ Site area	Ventilation details		Equipment Name	Equipment Functionality	Equipment Configuration (If any)	Equipment Aspiration value (m/s)	Equipment Local Extraction value (m/s)	Dust Analysis Study						Flammable liquid/gases properties				
			Type	Value (1/h)						Dust Type	Dust particle size	Dust Concentration (g/m3)	Minimum ignition Energy	LEL	UEL	Flash point	Minimum ignition temp	LEL	UEL	Specific density (Vapour/ gases)
1	Seed treatment	Treating Area	Natural Ventilation	1	Seed Treater	Seed treatment	01) Seed Treater, 02) Hopper, 03) Rotary Valve	NA	10	Combustible / Non combustible										

Figure 41: Sample equipment list to standardise across all sites.

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