Process Safety: Explosion Protection Equipment

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Abstract *— Nowadays as the Manufacturing Industry is growing, much of them create new facilities and others just make improvements in their existing facilities. But something that all of them need to take to consideration is their safety, especially is there is dust in their process. This time as others, the customer is adding equipment into their process and want to protect their equipment in the plant. The safety equipment to be implemented will not change anything in the customer process but will protect the same of possible explosion because of the dust. The DMAIC methodology was used this time to make possible a better understanding of the process. The safety equipment installed in the transfer pipelines will not interfere with the travel velocity of the product.*

Key Terms *— Dust, Explosion, Process Safety, Protection.*

PROJECT STATEMENT

Safety is for life. That is our slogan and we have a compromise with our customer to do everything in our hands to deliver the best solution for their protection. Along the time, the industry is being changing and becoming more sophisticated. The customer is looking to expand their production line which will include equipment that need to be protected. Also, they had a dust explosion that damage part of the existing machinery which was not protected. Nowadays, there are entities that strictly regulate the industry with an explosion or fire hazard, NFPA is the one that rules in United States. We will have to design depending on the machinery that the customer acquires and will have to take in consideration the location, position in the plant and what materials they will be working with. Most of the time, the product in its original phase, is not flammable because is presented as a solid piece but in its way to be a final product it will change the flammable characteristics.

RESEARCH DESCRIPTION

When we work with flammable materials, is important to know all the properties of it and the conditions that can push it to the point of create an explosion. Also, we have to understand the conditions that can lead this to happen, so we can prevent a catastrophe. Developing this study, we will know or at least have a better idea where things can go wrong and protect it by implementing the safety equipment. Another thing to be evaluated will be the type of machinery to be installed by the customer, specifications, material, and design.

RESEARCH OBJECTIVES

- Understanding the product that the customer will be working with in the plant and if it will be mixed at some point of their process.
- Evaluate the design and the position of machinery to be installed in the production line.
- Design taking in consideration safety equipment to be installed.
- Install the safety equipment.
- Start up (test) of the process, certify it as good to be operated.

With this Project we are looking to motivate other companies to protect their equipment's because is a requisite by law and in order to protect their facilities and much more important human lives. Also, we are trying to keep implementing the Safety Culture.

RESEARCH CONTRIBUTIONS

There are couple contributions that are very relevant, but I will say the design phase is the main

one. In this point we are evaluating and doing calculations to determine which safety equipment is the right one to be install in the machinery and why will be the best to be implemented. Normally this safety equipment works in combinations, so most of the time and depending on the process, location and design of the machinery we design to implement more than one.

Another contribution is the investigation to found more characteristics about the product they will be working with. That way we can safely design and choose the right size of the equipment to be installed.

LITERATURE REVIEW

All the industries around the world are regulated for different entities to conserve a standard and to make sure they follow the process. Also, there are insurance companies that require manufacturing companies (field where I work for) follow this entities rules to qualify for their coverage. In North America, exist a couple safety entities that regulate the manufacturing industry like OSHA and because in my case I am working in the industry that have dust hazard as an explosion risk the entity that rules is the NFPA which have different standards depending on the what type of dust we are going to deal with [1].

To have a dust explosion there are five components to make that possible.

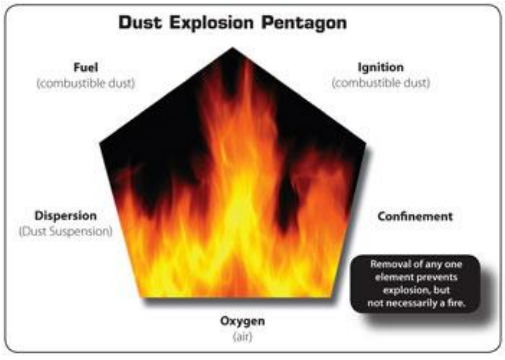

Figure 1
Dust Explosion Pentagon

First, we need the oxygen, which works as an oxidant and need to be present in all the combustion process in order to have the chance of create a flame. Does not matter its quality for this to happen.

As second component, is requiring to be in a confinement space which is very common, or I may say is crucial for the manufacturing companies process. A vessel is a confinement space which we can define as a space with limited entry and egress and not suitable for human inhabitants. Normally vented dust explosions are simulated using the computational fluid dynamics code FLACS-DustEx. As an example, there are Tanks, that occasionally entered by maintenance workers but not intended for human occupancy, Silos which normally storage the product in bulks, Ducts that transport the product from one end to another through the process, Dust collectors that are used to suck all the dust from the process, and other components as Cyclone, different types of Dryers, Storage areas, etc. [2].

Figure 2
Q-Box Flameless Vent

The combustible dust plays the fuel roll and we it can be defined as a solid material composed of distinct particles or pieces, regardless of size, shape, or chemical composition, which presents a fire or deflagration hazard when suspended in air or some other oxidizing medium over a range of concentrations. It can be sugar, flour, metal dust or other type of flammable product [3].

The dispersion of dust particles is needed in this pentagon to let the explosion happened. If we try to do an experiment and we put in a pot or a can, making the function as a silo, a certain amount of Common solids (like flour, sugar, etc.,) that can be suspended and transported in air via pneumatic conveying systems and through a match and then

close it, nothing will happen. But if instead we prepare the container in a way that somebody can blow inside, making a dust cloud and with the match inside it will explode [4].

Without an ignition source there is no explosion. There are many ways that an ignition can appear in the panorama to create an explosion. In the manufacturing industry, like food industry, is wood industry, plastic or paint industry, and others is almost imperative the use of ducts (pipes) to transport the product from one side to another and at the same time to collect the dust from the process. As an example, the static is one of the sources to create a spark inside a duct, which is why everything needs to be wiring to ground. Also, if by accident there is a metallic part (screw, piece of metal or other) that fell inside the ducts, it can produce a spark with the traveling and knocking the ducts walls.

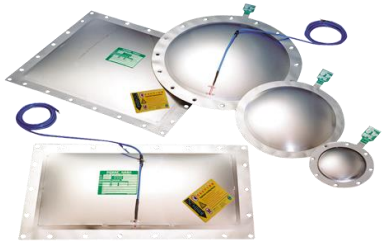

Figure 3
Rectangular and Cylindrical Explosion Vent Panels

This means that to occur an explosion, the combustible dust needs to be suspended as a cloud dust where the particles are dispersing and mixed with the oxygen.

Another source could be in the contact between metal parts to complete a process as the friction between gears or gears and chains or rollers, etc.

Part of the equipment that can be implemented in this process are the spark detectors which are very sensitive and after detect something, the system will shut down automatically to prevent mayor damage, in case of an explosion [5].

Depending on the product, the category and the strength of the explosion will change, making very important the design and the size of the explosion protection equipment.

METHODOLOGY

First step - Define: In this step we are briefing about the project, in what consist, establishing the objectives and goals, and planning how will be the approach to develop the project. In my case I am using my current job as a platform to create this step with the help of the modules from the class. Doing this, I am helping myself to develop more the efficiency on next projects on site. Also, I can improvement and learn more from projects already expose by other coworkers.

Second Step - Measure: To develop this step we first have to collect as much information as possible about the current process in order to help to determine the best design to protect the equipment we will be working with. All this data will be acquiring from the customer which is the one who knows the process of their plant and from the provide information from the manufacturer of the equipment in order to install and make functional the other parts to complete the process. In this collect process is included the project manager, the maintenance personal, and the contractors as mechanical, electrical and others that are part of this common process. Diagrams, pictures, technical data and plans are most of the data needed.

Third Step - Analyze: During this step, we will be calculating and evaluating the data obtained from the previous step. We are not going to evaluate in order to identify the root cause; instead we are going to eliminate all possible root causes of future damages or something that can lead to a failure or to cause an explosion. I would be ingenious if I say that much of the customers do not know that they need to protect their equipment by law, because there are standards in the industry to regulate this.

Fourth Step - Improvement: for this step, solutions are already on the table, the only decision that needs to be made is quantity, location and size. Since our equipment is suitable to be installed in the whole industry, the only calculations that we need to make is according the size of the equipment of the customer. At the end we have to vent all the pressure in a safe way to a safe area using our flameless vent

equipment. This are already tested at the production site before putting them ready to sell and a copy of their manufacture certificate with a manual are included.

Fifth Step - Control: To ensure and elongate the equipment life we introduce to this step the Equipment Service or maintenance, in order to sustain the improvements which, consist in monitoring the equipment doing tests every certain time as well checking the new process to avoid future problems. Services depend on the type of process, product and regularity and this can go from once a year to twice a year.

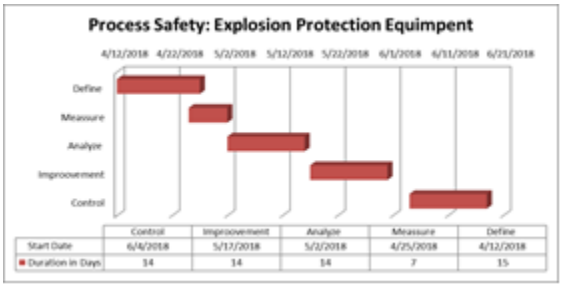

Figure 4
Gantt Chart of DMAIC Strategy

RESULTS AND DISCUSSION

Since we do not do installation of our equipment, there is a third party involve as a contractor which will for part of the team. The team that will participate in the execution of this project consist of the contractor company with the supervisor and two mechanical installers, one project manager for the company we are developing the project for, two designers from the company I work for including myself and the assistance of an electrical technician for the commissioning which will work with me hand by hand. The role of the team is to recollect data of the current process focusing on overall time of each step and held recurring meetings to analyze the data and brain storm possible solutions. These activities will be completed as part of a DMAIC measure phase.

Define Phase

The goal of this project is to prevent major damage to the equipment by reducing the chances of rise in pressure by detecting it on time and shutting down the system and in case of an explosion, be able to vent it through the flameless vent equipment and at the same time seal the transfer line pipes with the explosion protection valves to avoid propagation and second explosions.

Working this way let us avoid delays even though they are normally presented in the customer side, not in ours. Also, we are assuring that should not be rework in our side, but cannot say the same on the contractor side, we provide all the manual and support to make sure everything is installed properly. In the company I work for, we do not used to report constantly to the customer unless we need any information for completing the study or the design and because normally customer have schedules which they let us know their, so we are aware of the progress in the project.

Measure Phase

A 'VOC' table is generally conducted at the start of any product, or process in order to have a better understanding of what the client's wants and needs to obtain a more detailed product and its specifications. Customer is looking to complete their job in a time manner because of their product demand, but at the same time accuracy and quality must be present in the development.

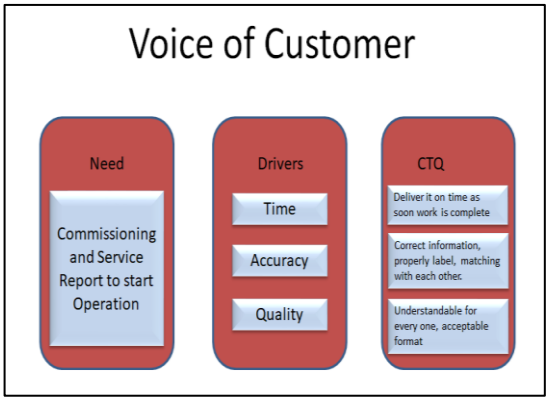

Figure 5
Voice of Customer

The most important drivers within the process of the Commissioning and Service Report are time, accuracy and quality, in which a critical to quality (CTQ) was define for each. CTQs are the main key

measurable characteristics of a product or process whose performance standards and specifications limits must be met in order to satisfy the customer.

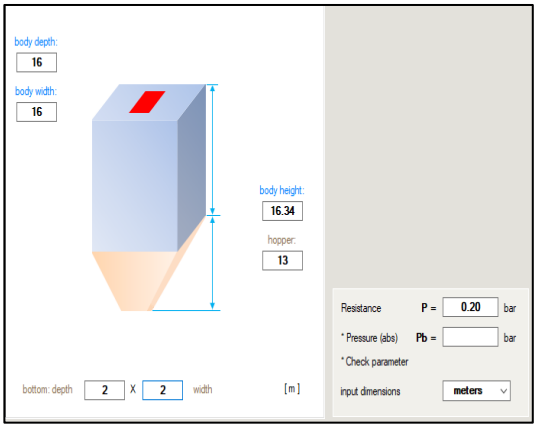

Figure 6
Complete Soy Beans Silo Dimensions

If CTQs are not established, quality can be impacted very significantly. From an organizational perspective, it could mean extra costs; rework, low productivity and wrong decisions can be taken because of outdated data. Project managers need to assure that data associated with their designs is both accurate and complete. This will not eliminate the need to evaluate the metrics during the measure process, but it will help understand the overall project as an indicator of the customer needs.

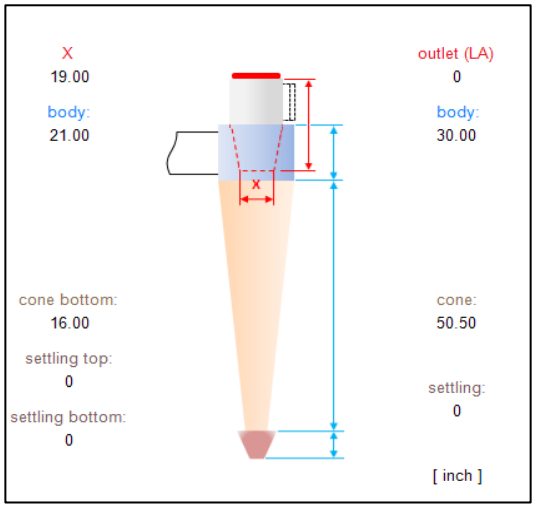

Figure 7
Cyclone Dimensions

This process has calculations that need to be performed in order to found a suitable solution for the customer equipment application. We are using a software designed to work with this type of applications in order to come up with a venting area, then work with sizes of the flameless vents to be use. The software is already loaded with graphs that represent the different shapes of the silos, cyclones; filter receivers, etc., of the equipment that we will be working with and the space to put in the characteristics or values of it to be calculated. In this project are three different systems interconnected and all of them needs to be protected.

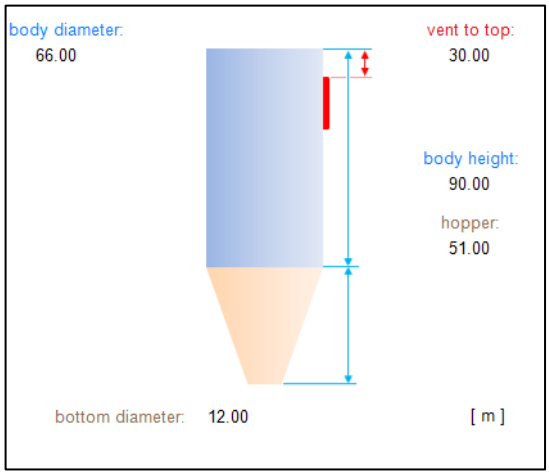

Figure 8
Sidewinder Filter Receiver with Targo Vent Dimensions

Analyze Phase

After work is done, the goal in the analyze phase is to identify the possible root causes of the delay or defective report which is develop for commissioning purpose as well as generation process. The Pareto chart can be used as a guide to identify major problems in the process. In the Pareto chart below we are using a scale of 10 jobs to run it and it can be observed that the top offender was missing data with a frequency of 9 times representing a 40.9% of all the total defects. Also, the chart is helping us to detect the areas where we need to improve in order to turn in the reports complete and without errors which make us work extra. Creating a check list to go through helps us make sure we touch the critical points before delivering the report.

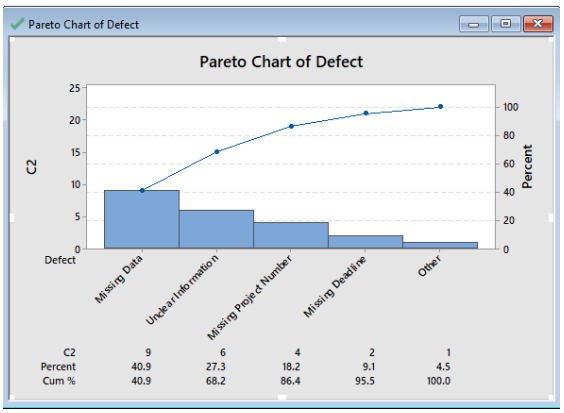

Figure 9
Pareto Chart of Defects

Improve Phase

The objective of this phase is to bring together solutions and implement them to solve the problems found in other phases. In order to identify all possible solutions, a study was held of where to look to avoid defects. Between the responsible of the reports was a meeting where criteria were made out of different categories to be evaluated in order to come up with a solution. The following are the principal solutions selected to correct the errors found in the reports. Also, the principal objective of the project was achieved; we protected the customer system by 99.99%. Normally we assure to our customer that their equipment or facilities were our systems are installed are protected a 100% and one the reasons that I have decide to left out the 0.01% is because sometimes there is a failure in the plant that can affect the area where our equipment are installed like power loss or air supply loss. This does not mean that they will be unprotected but definitely it can affect the functionality if this is going for a long period or continuously.

Control Phase

As we know, Control phase is the last step of the DMAIC model, with the purpose of making sure that changes implemented during the improvement phase are well documented and sustained. We can achieve that goal by standardize the process and creating different tools to help us improve. To help making the transition smoother, a complementary training of how to use the tools to achieve a good job was part of the process to teach the current and future personal in the United State location but also, in Europe and Asia locations. As a company oriented to the safety and that provide equipment to make a process more safety we have bring to the attention the documentation aspect, which is very important in order to identify opportunities for constant improvement making possible the measuring of the success and the validation of new processes. Also, in the industrial environment, documents are part of the day to day for all the activities in order to keep track of everything and for legal purpose.

CONCLUSION

As a recognized company and experts in the dust explosion protection industry, we receive many inquiries from different industries as Food, Pharmaceutical, Recycling, etc., asking for solutions to protect their facilities and equipment of any major incident. In this occasion we worked to found a solution for our customer which is in the Food industry. After performing a positive DHA (Dust Hazard Analysis) we found out that the product (soy beans) the customer is processing acquire its explosive characteristics in one of the phases and that the place where it is going to be contained needs to be protected. After implementing the DMAIC methodology we were able to meet the objectives established at the very beginning of the research. Also, according to our calculations we determine that the silos (container) were the product will be processed can have an explosion overpressure impact of 8.7 Bar which is 126.18 PSI and according to the DHA the product specification constant (Kst) can reach a maximum of 117 m·bar/s. In order to avoid some damage to the structure because of not enough vent area to vent all the pressure, we also calculate it and obtained 1.30 m^2 per vent equipment. An internal calculation gives us a total amount of 16 Explosion Flameless vent equipment that needs to be installed in order to protect the silos, as well 1 panel for the Receiver and 1 cylindrical panel for the Cyclone. Part of this project was developed a start-up and deliver a Service Reports of

all the information about the system and recommendation for maintenance and gives training about it to make sure everybody understand how to handle the equipment in different situations. The project was successful, and report was delivering on time.

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