Tools to assess the explosion risks in the chemical, pharmaceutical and food industry

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Explosion hazards exist in many unit operations of the chemical, pharmaceutical and food industry as e.g., milling, drying, pneumatic conveying and dust filters. The hazard exists due to the combination of the presence of explosive atmospheres (flammable gases and vapors, combustible dust or hybrid mixtures) and potential ignition sources (e.g., electrical and mechanical sparks, static electricity discharges, hot surfaces and glowing nests).

1. Tools for the assessment of the explosion risks

The Swiss Safety Institute developed tools in order help companies in the assessment of the explosion risks. These tools are based on a long year experience of the Swiss Chemical Industry. The methodology is based on the following steps:

- To define which experimental data from the substances is needed for the assessment
- To define a systematic procedure to assess the risks and propose safety measures for different types of equipment based on the results of the experimental measurements.

The tools are the following:

- Worksheets
- Supporting documents
- In- house courses and E-learning

1.1 Worksheets

There is one worksheet for every equipment group performing unit operations, e.g,

- Convection dryers
- Spray dryers

- Fluid bed dryers/ granulators
- Sieves
- Mills

They contain a list of safety measures depending on the safety data of the products.

In addition, there are also worksheets related to other operations of powder handling, such as e.g., charge and discharge of equipments, pneumatic transportation or dust filters.

1.1.1. Determination of safety data

Some safety basic data of the substances to be handled are essential in order to assess the explosion risks of any unit operation. Those are e.g.:

- Impact and friction sensitivity
  - Many processing equipments impose mechanical stress on the substance, such as e.g. pin mills or paddle dryers. Only products that are not impact or friction sensitive could be handled.
- Burning characteristics (Combustbility index)
  - This property refers to the burning behavior of the materials (mainly how rapidly it burns and if once ignited, the fire is able to propagate). Knowing this property allows deciding which type of fire fighting measures are needed. For example, if a product to be dried burns rapidly it may be recommended to install an automatic water deluge system into the dryer.
- Minimum ignition energy
  - This parameter determines the sensitivity of the explosive atmospheres to ignition sources, especially static discharges. For flammable vapors and gases, the values can be easily obtained from literature. For combustible dusts this property depends on many characteristics of the product (e.g. particle size) and should be determined. As an example, in dust filters if the minimum ignition energy is very low (e.g. < 3 mJ) constructive explosion protection measures are recommended.
- Minimum ignition temperature (dust cloud or flammable liquid)
  - This temperature is necessary to determine the temperature classes of the electrical equipment.
- Smoldering temperature (dusts)
  - This value is necessary to define the maximum allowable temperature of surfaces where dust layer of combustible dust may be formed.
- Thermal stability
  - Thermal stability should be known in order to define e.g. safe drying or hot discharge temperatures. A special property related to the thermal stability is the ability of a substance to undergo spontaneous self-decomposition. In this case the product may not be handled safely

in equipment where hot spots may be present (e.g., paddle dryers)

In addition, different unit operations may need additional data or different approaches to the basic data.

Consider as an example a vacuum dryer: the product will stay under vacuum at high temperature during long times. In this case, the thermal stability tests used for the assessment could be performed in closed crucibles: the influence of air in the thermal stability measurement is not relevant. Afterwards, the dry powder may be transferred to Flexible Intermediate Bulk Containers (FIBC): in this case the thermal stability should be assessed based on wire basket tests in order to take into account the influence of air.

1.1.2. Classification into risk groups

Depending on the safety data the products will be classified into a risk group e.g.

Group A: no critical burning or explosion characteristics
Group B: combustible dust without flammable solvents
Group C: combustible dust wet with flammable solvents
Group R: especially dangerous material (e.g. impact sensitive)

1.1.3. Choice of safety measures

Every worksheet contains specific safety measures for every substance to be processed according to its risk group.

Table 1 Example of worksheet

Safety data					
Impact sensitivity	No				Yes
Flammable solvent	No			Yes	
Minimum Ignition Energy < 1J	No		Yes		
Burning number	1-3	4-5			
Risk group	**A**	**B**	**B**	**C**	**R**
	↓	↓	↓	↓	↓
Safety measures (examples)	**A**	**B**	**B**	**C**	**R**
…Control of mechanical vibrations	X	X	X	X	
…Grounding of all conductive parts		X	X	X	
…Eliminate non conductive surfaces				X	
...Individual risk analysis is necessary					X
...Automatic water deluge system		X			

The safety measures proposed in the worksheets may help to decide, which type of equipment is suited for a specific application. For example a producer using a spray dryer without constructive explosion protection measures for thermally stable products may notice that new equipment would be necessary if a new thermally unstable product should be handled.

1.2 Supporting documents

Some equipment needing specific explosion protection concepts are described in more detail. As an example, the explosion protection concept for a fluid bed dryer could be described in more detail:

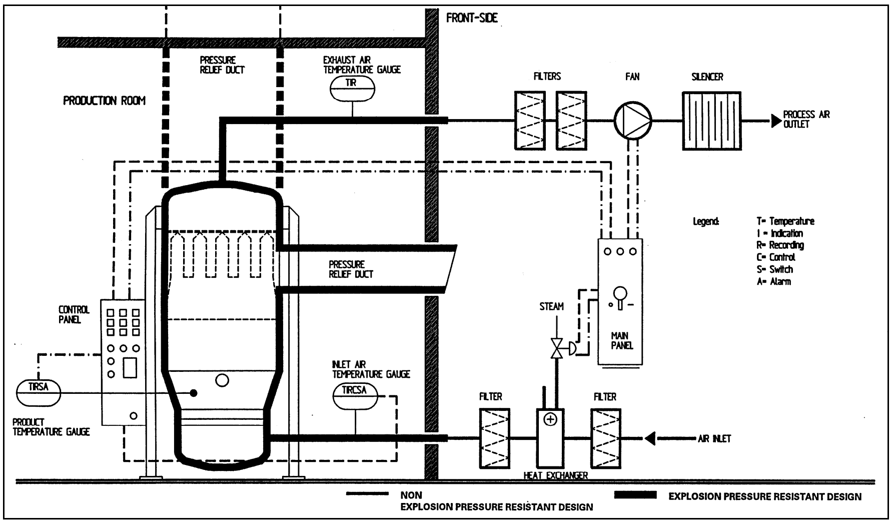

Figure 1: Example of an explosion protection concept for a fluid bed drier

1.3 In-house courses and E-learning

In house courses and an internet- based software tool providing training in how to use the worksheets are other important elements of the system.

In-house courses are needed in order to raise awareness and provide an in-depth knowledge to a selected team of professionals of the theoretical basis on which the decisions taken with the worksheets are based.

Internet- based software tools are a support for refreshing the knowledge and help training the collaborators that couldn’t attend the in-house courses.

The E-Learning concept consists in the following elements:

- The E-learning contents: e.g. a power point based presentation
- The E-learning path: the systems guides the student through the contents
- Control questions: allow the student to test his understanding of the content. If a false answer is given, the question is repeated or a contact with an E-coach is proposed.
- Practical tasks: after completing a module the student is asked to solve practical problems in his own plant.
- A reference book: including a glossary and a theoretical justification of the safety measures proposed by the worksheet.

2. Important features

The system can be easily integrated in the Safety Management System and provides:

- Full ATEX compliance
- Takes into account the hazards related to static discharges (CENELEC and TRBS 2153)
- High flexibility in the determination of thermal properties of the material (based in the results of up to six different methods)

2.1 ATEX compliance

The ATEX 137 requires the elaboration of an explosion protection document based which should include an explosion risk analysis. The worksheets perform this risk analysis using the "check list" technique. They can be referred in the explosion protection document.

2.2 Risk related to static discharges

The risks related to the static discharges are often not well known and difficult to assess. The system provides theoretical information (E-Learning) and practical advise (Worksheets) in order to control this risk.

2.3 Thermal properties of the materials

The thermal stability of the substances may be determined using different experimental devices. Some of them allow the contact of the sample with air in order to determine its influence on the thermal stability:

- Grewer test (8 ml wire basket)
- Wire basket test (e.g., 400 ml)
- Radex

Another devices perform the measurement in containers with low contact with air as e.g.

- Lütolf test
- Differential Scanning Calorimetry (DSC)

The tests are selected according to the unit operation to be performed (e.g. DSC for vacuum drying and wire basket test for a spray drier). The experimental techniques have different accuracy; the tests having more accuracy are usually more expensive. The worksheets define a set of rules based on the results of different tests in order to define the safe temperatures of operation.

3.Conclusions

The tools developed allow a systematic and efficient assessment of the explosions risks related to unit operations (e.g. drying, grinding, powder handling) in the pharmaceutical and food industry. There is a long experience on the use of these tools worldwide as a part of the Safety Management System of large corporations. The extension of the use of these tools to small and medium companies could be promoted e.g. by industrial and professionals associations. This will help these companies to comply with the legal requirements of ATEX in an efficient manner and to reach a high level of safe operation.

4.References

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    c. Nr. 5: Milling of combustible solids
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2. Bundesministerium für Arbeit und Soziales (Germany), TRBS 2153: “Vermeidung von Zündgefahren infolge elektrostatischer Aufladungen”, (2009)