Summary

Within the field of dry bulk materials handling it is known that dust explosions can be hazardous. Everywhere where bulk handling takes place one of the important factors to know is the sensitivity of the handled materials for self-heating, fire and explosions.

Ongoing research in the Marine and Transport Technology department of the Delft University of Technology is on the design of a biomass bulk terminal in which large amounts of wood pellets and wood chips will be handled and stored. When designing these facilities it is important know what the implications are due to dust explosiveness. Therefore, the main research question in the report is:

What are the implications for the design of a biomass bulk import terminal when looking at dust explosion safety?

To answer this question, first the theory on dust explosions is researched. A dust explosion can be described as an exothermal chemical process that, when occurring at constant volume, leads to a sudden and significant pressure rise, the fuel for this reaction are small particles suspended in air.

For a dust explosion to occur, five ingredients, also known as the 'dust explosion pentagon', are required. These ingredients are

- a fuel, in the case of dust explosions the fuel consists of combustible dust;
- an oxidizer, which provides the oxygen for the chemical reaction;
- the concentration of the dust must be within the explosibility range;
- an ignition source to start the chemical reaction;
- confinement to create the pressure rise.

A dust has several explosion characteristics that relate to the ignitibility and explosibility of a dust cloud. Such as

- minimum dust concentration;
- maximum explosion pressure;
- maximum rate of pressure rise;
- minimum ignition temperature;
- minimum ignition energy.

These characteristics depend on important factors such as the chemical composition of the dust, the particle size distribution and turbulence within a dust cloud and the initial temperature and pressure of the dust clouds.

Examples of dust explosion incidents show that dust explosions can be devastating, even when workers are instructed on the matter. Two national dust explosion databases show an increasing trend

in the number of incidents, but the number of deaths and injuries per explosions seems to be relative constant over the years.

The danger of dust explosions calls for safety measures. Among these safety measures are the European ATEX regulations, which state that potentially explosive areas should be marked depending on the frequency and length of the explosion hazard. In these zones only certain ATEX certified products may be used. Other, more concrete, standards were developed in the United States.

To analyse the influence of the material properties on the design of a bulk terminal, a biomass- and coal terminal are compared in terms of dust explosion theory and history cases. Some material specific standards are also involved in the design.

Preventing and mitigation dust explosions can be done by the means presented in this report. To know which means to implement, details about the processes and materials have to be known. In addition specific hazard studies have to be done. These studies can point out the exact prevention and mitigation means that are to be implemented in the design. When designing a bulk terminal one could implement all the means for prevention and mitigation of dust explosions to minimize the explosion hazard. However, the costs for this would be very high, and it should be question if the costs are worth the extra safety the means provide. A cost-benefit calculation would have to be made for every safety measure.

Following this report, some recommendations can be made for further research. To give a complete answer to the main research question in this report, some further research has to be done. This research should focus on the exact material properties of the materials that are to be handled and stored, the lay-out of the terminal, including all the needed equipment, and the processes in this terminal. Only then, with help of the various standards, regulations, and protection and mitigation means in literature, all the design implications can be concluded.