Fire and Explosion Hazards in the Biomass Industries

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Biomass take numerous forms including wood chip, wood pellets, dried sewage sludge etc. In addition there is extensive use of wood chip and "wood flour" in the chipboard, Fibre board and MDF manufacturing industries. This paper deals principally with the use of bulk biomass used as a fuel, but may be equally applicable in any other industry where bulk biomass is used, processed or stored.

In recent years there has been a vast increase in the use of biomass as "alternative energy" or "green fuel". Biomass comes in many forms, the most common for industrial sized applications being wood chip or wood pellets. There is also extensive use of wood chip and wood "flour" for use in the production of chipboard, MDF and laminate flooring.

Thus, wood chip and wood pellets are being transported and stored in ever larger quantities. The increase in use and storage has been accompanied by an increase in the number of fires and explosions in biomass storage and production plants. The largest use of biomass in recent years has been due to the increase in the use of wood as an alternative fuel in power stations and in many smaller scale industrial heating systems.

Fuels used to date include pellets from sources in North America, Europe and elsewhere, recovered wood, mainly from UK sources, wood chips from various sources, and waste forest materials (principally small diameter branches and sawdust turned into pellets). BS EN 17225 [Ref.6] describes the types of fuels commercially available, and specifications intended to be used for supply. It explicitly says however, it is not intended to be used as a specification for industrial use, and part 2 of the standard covers wood pellets. The specification covers ash content, calorific value, water content, particle size distribution and elemental analysis, particularly for heavy metals, all of which are important for various reasons, but does not provide information to design, construct and operate a "safe" system.

Typically, the content of MDF may be up to 60% recycled wood whereas wood pellets for heating boilers are typically wood waste from sawmills etc and larger scale installations often use wood chip specifically intended for power generation purposes.

Biomass is an inherently dangerous category of substances, especially in bulk and has significant fire and explosion hazards. In particular, the tendency for self heating and the difficulties in early fire detection and fire fighting present a number of unique challenges. In many cases, it appears that lessons learned many years ago in the safety of these materials have been forgotten in the rush for "green" energy.

Regardless of the type of material used, there is an extensive list of fire and explosion incidents relating to the storage and use of biomass. A small selection of typical biomass industry incidents is listed in the table below:

Date	**Company / Location**	**Description**
2002	Sonae, Merseyside	Dust explosion. MDF production plant. 17m diameter hole blown in building wall. 1 serious injury
2011	Sonae, Merseyside	Fire in wood chip storage hopper, burned for over a week. 1 fatality.
2013	Port of Tyne	Wood pellet fire in conveying system
2012	NPOWER Tilbury Power Station	Wood pellet fire, 6,000 tonnes burned for 4½ days, controlled by application of foam. *"...biomass pellets added unprecedented challenges as to how to tackle, suppress and extinguish this fire" Tilbury Fire & Rescue*
2012	Dong Energy:Gelderland Power Station, Netherlands	Dust explosion, wood pellets
2013	Egger Hexham	Chipboard Factory, fire in biomass incinerator
2013	Koda Energy, Minnesota	Explosion and fire in biomass storage
2014	R Plevin Recycling, Yorkshire, UK	Fire in wood chip pile. 3,000 tonnes of wood chip destroyed, 10 days to extinguish
2015	Southampton Docks	Woodchip stack, major fire
2015	Boseley Wood Mill, Macclesfield UK	Dust explosion, 4 people killed

It is notable that the number of biomass incidents appears to have increased more or less proportionately to the number of large scale biomass installations. In the dash for green energy it appears that we have forgotten lessons learned on the safety of bulk storage and transportation of combustible and explosible materials.

Bulk Storage of Biomass

Bulk storage is something which has increased as the use of biomass has increased. Storage can typically be found at:

- The point of production as raw material for dispatch
- Transport interchange points e.g. rail to ship
- Recycling centres
- Pellet production facilities
- End users

Generally, bulk storage falls into three types:

- Open mounds (outdoors)
- Hoppers or silos
- Sheds containing mounds (flat floor storage)

Open mounds are often found at recycling centres and wood chip production and also at ship offloading facilities. Hoppers or silos are commonly found at end user facilities. Flat floor facilities are commonly used for finer materials where the material may be affected by weather or to protect from rain and wind. Wood flour and small wood chip are not suitable for storage in the open because of the potential for dust pollution and a therefore mainly stored in silos or on flat floors.

Biomass, whether wood chip, sawdust or flour, is prone to self-heating. This is one of the major cause of fires within the biomass industries and is a particular problem where there are large quantities of material stored in a single silo or pile, and where material is damp.

Storage units currently being built in the UK and elsewhere are an order of magnitude bigger in scale than anything previously built previously for handling similar products having a risk of fires or dust explosions. As the plant scale increases so the self-heating of the bulk stored material becomes inherently more difficult to control. In addition, for dusty materials, there are issues in providing adequate explosion relief. This is also discussed further below.

Storage Time

Biomass will deteriorate over time as it is an unstable material. The current state of knowledge means that it is not currently possible to estimate the maximum safe storage period for any given product, especially as the quality of biomass can vary considerably from batch to batch. It is, however, possible to make some general recommendations:

- If any given storage unit is showing a higher temperature than other units on the installation than this should be used first as it is likely that the higher temperature may be the early onset of burning.
- Stock rotation is essential, operating on a First In First Out (FIFO) system, ensuring that silos or stores are emptied completely.
- Spare storage space should be retained so that any suspicious load can be removed and isolated

The safe storage time may also be affected by the level of humidity within the biomass store. Generally, higher humidity leads to more self-heating issues as does a lack of air circulation through the storage. [Ref.11]

Transport Hazards

Ship & Rail

Bulk biomass is often transported by rail or ship. The larger scale of ship movements in particular gives rise to potential for self heating and fire, particularly given the risk of water ingress into the hold and inherent large capacity of modern bulk carrier ships. In many cases, the issue of self heating may not become apparent until the hold covers are removed for offloading when oxygen ingress may result in a sudden flare up and potential explosion.

Conveying

Typical conveying methods for biomass are most commonly ether conventional belt conveyors or pneumatic conveying systems. Belt conveyors are prone to build-up of dust along the conveyor length which can then be ignited by frictional heating. British Coal [Ref.12] showed how certain types of conveyor bearing were prone to catastrophic collapse and the subsequent generation of a high energy ignition source. It should be noted that even ATEX compliant idler rollers are prone to failure and frictional heating. All types of roller may give minimal warning of imminent failure.

Pneumatic conveyors have a lower capacity than belt conveyors and can also be noisy in operation. They also have the potential to create dust clouds when being transferred into silos at the end of the conveying run.

Bucket elevators are an energy efficient means of lifting bulk biomass but are known to cause clouds of dust for dusty materials and are also a potential source of ignition due to mechanical failure. Bucket elevators can also enable the transmission of explosions between various sections of the plant and are difficult to protect other than by the use of explosion venting or suppression.

Early detection of mechanical failure is a key and this may be achieved by belt slip monitoring and belt alignment monitoring. Periodic mechanical inspection and maintenance is also strongly recommended to minimise the risk of failure. In addition to explosion protection, measures should be taken to provide explosion isolation at either end of the elevator in order to prevent explosion transmission and pressure piling. There is a CEN report in preparation for bucket elevators (2015) which should provide further information, but this had not been published at the time of writing.

A strategy should be put in place for the appropriate action to be taken on detection of a fire on a conveyor. This may include the controlled dumping of the affected materials via a divert conveyor and cessation of unloading. Consideration should be given to the reliability of detection and the likelihood of a false positive. This may include physical inspection of the material on the conveyor prior to restarting transfer.

Screening of Biomass

In all cases, pre-screening of biomass is recommended to ensure that:

- Burning material is not being passed through the system thus transmitting a fire
- Removal of tramp metal (ferrous and non-ferrous)

Screening is particularly recommended where there is a reduced confidence in the quality of the materials being received. This is often a particular issue for recovered wood where there is a high risk of tramp metal particularly and also a highly variable quality of the wood itself which will probably contain a variety of hard and soft woods plus chipboard, MDF etc, all of which have different flammability properties.

Thus, a multiple level screening regime may be needed typically comprising:

- Coarse screen for oversized tramp materials
- Magnet for removal of ferrous metals
- Eddy current detection for non-ferrous metals
- Heat detection for hot spots

The rate at which tramp materials are collected is a good indication of the overall quality of the biomass. Poor quality should be addressed with the supplier as this is a potential safety issue for the system. It should be noted that the bulk temperature of the biomass should always be monitored, especially when unloading or transferring between locations where the material has been kept for some period e.g. when offloading from a ship.

Dusty loads of biomass can present significant explosion hazards and the amount of dust being generated during the transfer of the material should be monitored. Any particularly dusty loads are an indicator of poor quality biomass.

Design for Blockage

As with all solids handling systems, blockages are more or less inevitable at some time during operation. The self heating properties of biomass make it essential that blockages are cleared in a timely manner before the material in the blockage can self-heat to a fire scenario. Thus it is important that appropriate access is provided for the removal of potential blockages from any conveying systems. This can be particularly difficult for underground or aerial conveyors. The early detection of blockage is also important and flow monitoring and CCTV systems should be installed at key locations so that early warning can be gained of any problems in the system. Blockages can develop and escalate rapidly and hence it is essential to stop the feed immediately on detection of any blockage if a large pile of trapped material is to be avoided. Ideally, an automatic alarm system should be installed to detect blockages or stoppage of flow.

Note that the removal of blockages may require the isolation of moving equipment such as conveyors, valves and augers and the access of personnel into confined spaces. Confined space entry is covered in detail below in this paper.

Fire Detection in Bulk Storage

Early fire detection is important if major fires are to be avoided. The detection of fires in biomass is, however, not always straightforward. Wood chip and sawdust is an excellent insulator and so conventional heat detection can be ineffective as the outer layer of material may well be at ambient temperature whilst the core temperature may be more than 200°C.

Cable type detection can be used, but is prone to damage during filling and emptying and is therefore not generally recommended. Point localised detection can also be used but is generally of limited value due to temperature gradient effects. Monitoring of the temperature trends is generally more useful than the temperature at any given point or time. A steady increase in silo temperature can indicate the onset of thermal decomposition. It should be noted that the early onset of fire within a large silo can be very slow and thus the initial temperature rise can be very gradual. Thus, a long term temperature trend graph can be very useful in detecting early onset of heating before the situation becomes severe.

There are several other useful options for fire detection within silos, in particular, CO detection can be useful as can detection of volatile decomposition products. In this case, multi-gas detectors are recommended. Concentrations of >0.5% CO are a good indication that internal heating of the silo is occurring. CO levels >2% will generally indicate the presence of a fire. Similarly, hydrocarbon levels > 100ppm may indicate ongoing heating and levels >5000ppm may indicate the onset of a fire.

There is a wide choice of gas detection equipment available and the selection of the most appropriate equipment should be undertaken at an early stage of design. All gas detection equipment should be suitable for use in areas where flammable gases may be present. This means that a DSEAR assessment must be carried out and that the detection equipment must be ATEX approved. The use of ATEX equipment is discussed further below.

There are cases of overheated or burning biomass being received directly from the transport feed to the silo. In this case, burning clumps of material carried forward in the conveying system can dedetected by heat detection systems and effectively dealt with via water spray or sprinkler systems whilst on the conveyor.

Explosion Protection

Silos

There has been much work on the explosion protection of silos in particular the provision of explosion venting. [Refs. 4 & 5] The equations in these references are limited to a maximum volume of 10,000m³ and extrapolation beyond this value is potentially hazardous. The size of biomass silos at import reception facilities and power stations is likely to considerably exceed the maximum volume for the correlations, with several modern installations being an order of magnitude larger.

Thus, it is problematic to apply the existing explosion venting correlations where the size of the silo exceeds the maximum valid size of the correlation.

CFD modelling can be used to estimate the required explosion vent size and a small number of companies have carried out such calculations. It should be noted that the assumptions made during the CFD model can have a significant impact on the accuracy of the calculations and thus the validity of any key assumptions should be validated wherever possible. Effectively, the CFD model validation is based on experiments carried out in 200-300m³ scale units.

Filters

Dust filters require explosion protection, but these are normally protected with explosion vent panels. The design and location of these explosion relief panels is critical as they should vent to a safe location where the blast and flame will not impinge on personnel. It should be noted that the flame from a dust explosion panel on a large filter can extend to well over 15m from the blast panel.

Explosion Isolation

The transmission of an explosion through a biomass transport and storage system is extremely hazardous and must be prevented. Since the pressure front travels in front of the flame front in a dust explosion, pre-pressurisation of equipment can occur leading to a phenomenon known as “pressure piling”. Pressure piling leads to an increase in maximum explosion pressure and also increased rate of pressure rise. It is not generally possible to design an explosion vent for pressure piling.

Explosion isolation can be achieved by several means, e.g. ensuring that there is always a “heel” of material in the base of a hopper or rotary vane valve. Pressure piling may also be prevented by the positioning of explosion relief panels at changes of direction.

Fire Suppression & Fire Fighting

Inert Gas

For large silos, it is possible to use inert gas to “smother” the fire before flaming burning commences. The most common gases being CO2 and N2. Inergen and similar materials are generally too expensive to be credible for use in large systems.

The use of CO2 gives the potential for generation of CO gas, which is also flammable and hence CO2 should only be used with caution. N2 may be supplied from tanks or a PSA unit. For large silos, the overall system capacity and instantaneous supply rates can be an issue and require careful design. It should be noted that there are cryogenic and asphyxiation hazards associated with all inert gas use.

In practice, the inert gas blanket may need to be maintained for several weeks until the silo has cooled.

Water Systems

The addition of water to large silos can cause issues since pelletised materials can swell on water absorption. The addition of large quantities of water can also cause structural collapse of the silo due to the extra weight, especially in combination with pellet swelling. Water is, therefore best used to extinguish immediate flaming fire situations, backed up by inert gas. The type of water spray is also important since direct jets may disturb the pile. Generally, water sprinklers should be employed where possible, and in some cases, fogging systems may be beneficial.

Foam Systems

Foam systems hay have an advantage over water systems because of their ability to “smother” a fire but sitting on top and denying oxygen. Foam systems may also be useful where inerting is not a practical option due to the type of storage e.g. flat floor installations, or where the size of the installation means that inerting is not practical. There is also a risk with foam systems that oxygen is entrained into the foam system thus providing additional oxygen to the fire. Thus the design of the foam system must be done by a company with expertise in this area.

The design and operation of foam systems is not always straightforward and foam itself is an expensive material to purchase.

Well Established Fires

Where a fire is well established e.g. in a large pile (outdoors) the only way to tackle it may ultimately be to break open the pile to get to the source. This must be done carefully as the introduction of oxygen to hot sections of the pile may cause it to flare up spontaneously. Large quantities of water may need to be used to control the fire, and as a consequence, there may be an issue with fire water run-off pollution.

Small Scale Installations

Numerous small scale biomass installations are being built to supply fuel for "green" heating systems. These typically involve the installation of a biomass storage silo plus a conveyor to a package heating boiler. Other small scale installations involve the use of a "walking floor" type feed system to a boiler feed conveyor.

There are recorded instances of fires even in relatively small scale installations e.g. lass than 1,300m^3 capacity silos where self-heating has occurred leading to a fire. On installations where pelletised materials are used and there is a dust explosion potential and the installation of appropriate explosion protection should be considered. The main risk from small scale installation is, however, from fires in the storage, especially if the store is under sub-optimal conditions e.g. subject to external ambient high temperatures or water ingress, or where the rate of use of biomass may periodically be very low leading to excessively long residence times in storage with consequent self-heating.

Oxygen Depletion

The section on legislation (below) refers to confined spaces. This is a particular issue with biomass storage due to the slow decomposition of biomass materials and consequent usage of oxygen in the atmosphere. This can be an issue in any space where biomass is stored without adequate ventilation and may include, for example:

- Ship holds
- Flat floor storage rooms
- Silos

The slow decomposition can cause the generation of carbon monoxide and also displacement of oxygen by volatile hydrocarbons. Carbon Monoxide is a particular problem due to the toxicity of the material and the speed at which it affects humans who breath the substance. CO is toxic in concentrations greater than 35ppm and is not easily detected being colourless, odourless, and tasteless.

Several fatal accidents have been reported due to CO poisoning but one in particular relates to biomass, that being a case in Sweden [Ref.9] where personnel entered a ship cargo hold containing biomass where there was a significant amount of CO present. This resulted in one fatality and one significant injury plus five smaller minor injuries.

The ship cargo was pelletised wood which was being unloaded by crane from the hold. Due to the configuration of the equipment, it was necessary for personnel to enter the hold where two men were overcome by the oxygen depleted, CO rich atmosphere. It should be noted that the level of oxygen depletion in storage silos can reduce the oxygen level to less than 10% where there is minimal ventilation.

The HSE website states that between 2010 and 2012 there were at least three deaths directly related to biomass, these include two workers and one householder:

- *In November 2010 a 38-year-old male householder in Ireland died after entering the 7 tonne wood pellet storage room for his boiler. His wife and another man were treated in hospital after trying to pull him to safety.*

Even small quantities of biomass can produce sufficient oxygen depletion to cause risk to life. There is a number of factors that affect this:

- Age – pellets will produce more carbon monoxide within the first few weeks of being manufactured. Other biomass will similarly be more active in the first few weeks
- Temperature – more carbon monoxide is produced at higher temperatures due to the increased reaction speed
- Wood type – pellets made from pine contain more unsaturated fatty acids than e.g. spruce and so produce more carbon monoxide.
- Surface area – exposed pellet surface area and amount of mechanical abrasion of the pellets (leading to increased surface area due to dust formation)
- Oxygen levels – carbon monoxide levels will also increase with the amount of available oxygen present i.e. available to be converted to CO

Precautions are required for entry to all confined spaces where biomass is present due to the risk of oxygen depletion and CO generation. This should include testing for CO and oxygen levels prior to the entry of personnel into the area. Additional protection may be given by fixed CO and oxygen concentration alarms in areas where periodic access may be required.

All potential confined spaces should have suitable warning signs installed as well as suitable precautions against unauthorised entry under the Confined Space Regulations (see below). The sign should read: Danger – Risk of Carbon Monoxide Poisoning as a minimum with additional information as required including:

- Check atmosphere before entry with an appropriate device.
- No entry for unauthorised persons.
- Keep children away from the storeroom.
- No smoking, fires or naked flames.
- The room should be adequately ventilated before entering.
- Keep the door open whilst inside.

The UK HSE Website gives further guidance [Ref.10].

Relevant UK Legislation & Guidance

The primary UK legislation is the Health & Safety at Work Act (HSWA) [Ref.8], enforced by the HSE, which imposes duties on those are responsible for operating a completed facility (Section 2), and those who 'supply articles for use at work' (Section 6). However the application of these sections to a complete turnkey facility delivered by an EPC contractor are unclear. The Fire Safety Order (FSO) [Ref.13] which is largely enforced by the local Fire Brigade is also a key piece of legislation pertaining to biomass installations.

The FSO or "Regulatory Reform (Fire Safety) Order" 2005 Ref.13] imposes requirements for a fire risk assessment to be undertaken which must consider escape in case of fire plus requirements for fire alarm systems, fire-fighting equipment etc. High level requirements relating to the control of the fire risks caused by machinery are set out in BS EN 13478 [Ref.14]. An equivalent document setting out the framework for controlling explosion risks is published as BS EN 1127-1 [Ref.15].

The Supply of Machinery (Safety) Regulations 2008 impose requirements on those who supply machinery for a very wide range of applications. Specifically, machinery should be designed 'to avoid all risk of a fire or explosion, caused by the machinery itself, or the materials it processes'.

The Provision and Use of Work Equipment Regulations 1998 (PUWER) [Ref.16] imposes requirements on the end user for the safety of equipment in the workplace. For biomass systems this may relate specifically to machinery or equipment intended for use in a potentially explosive atmosphere which should meet the requirements of the relevant supply regulations (including DSEAR).

The Confined Spaces Regulations 1997 [Ref.17] place duties on employers with respect to safety in confined spaces e.g. due for the potential for asphyxiation or being trapped by process materials such as biomass. This legislation is common on many large plants. If possible, the number of "confined spaces" on the installation should be minimised.

The Dangerous Substances and Explosive Atmospheres Regulations (DSEAR) 2002 impose duties for the protection of personnel against fire & explosion hazards arising from the use and storage of "dangerous substances" in the workplace. Dangerous substances include flammable dusts which are capable of creating flammable atmospheres and have explosion potential. Self heating biomass materials are also regarded as being dangerous materials.

DSEAR and Hazardous Area Classification

The DSEAR legislation [Ref.1] covers the protection of personnel against fire and explosion hazards in the workplace and is applicable to the majority of biomass installations. It is a key piece of legislation relating to the safety of biomass installations. DSEAR is based on the ATEX directives for EU nations, applies to those who operate biomass facilities because the dust they contain is capable of forming explosive atmospheres, and also because the tendency to self-heat may mean that the bulk biomass should be considered as a Dangerous Substance.

There are three key regulations in DSEAR, these being:

Regulation 5	Carry out a DSEAR Risk Assessment specifically for the protection of people from fire & explosion hazards in the workplace
Regulation 6	Implement a hierarchy of risk reduction measures as defined in the regulation
Regulation 7	Hazardous Area Classification. Defines the areas where a flammable gas, vapour or dust cloud may occur and the persistence of the flammable atmosphere

The HSE DSEAR Approved Code of Practice L138 [Ref.3] also contains information regarding the risk from dusts as follows:

Paragraph 104 'The risk assessment should include consideration of whether work processes may give rise to dusts in sufficient quantity to pose a risk of injury if ignited. The employer should consider the potential for the incident to escalate. Account should be taken of possible accumulations of combustible dust which could be launched and dispersed into the air during an incident resulting in the formation of an explosive atmosphere'

Unfortunately, BS EN 60079-10-2 "Area Classification" (for dusts) [Ref.2] gives little advice on compliance which is directly applicable to biomass facilities, and nor is the HSE ACOP L138 particularly helpful in terms of complying with DSEAR for biomass applications. Technically, some forms of biomass may not be classified as DSEAR "dangerous substances" but any form of biomass containing dust definitely will be classified as a dangerous material. In particular this applies to wood pellets which tend to form dusty residues during transport and recycled wood which has been passed through a chipper. In practice, any biomass generating CO (flammable) may be regarded as being a dangerous material.

Areas are classified into "zones" according to the persistence of the flammable atmosphere. Zones are defined within the DSEAR legislation (Schedule 2) as follows:

For gases, vapours and mists:

Zone 0:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist, is present continuously or for long periods or frequently.
Zone 1:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist, is likely to occur in normal operation occasionally.
Zone 2:	A place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist, is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

For dusts:

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.
Zone 21:	A place in which an explosive atmosphere in the form of a cloud of combustible dust in air, is likely to occur in normal operation occasionally.
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

These periods are often defined as:

• Zone 0 or 20: Flammable atmosphere for typically >1,000 hours / year

• Zone 1 or 21: Flammable atmosphere for typically between 10 – 1,000 hours / year

• Zone 2 or 22: Flammable atmosphere for typically <10 hours / year

Equipment for Use in classified or "Zoned" Areas

Equipment for used in zoned areas must be "ATEX" certified and meet the appropriate criteria for Zone, Gas Group and Temperature Class of the gases and dusts typically found in the area. This is covered in the UK by the Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations. Where there is risk of a flammable dust, gas or vapour atmosphere then ATEX certified electrical and mechanical equipment will need to be installed in order to minimise the risk of ignition. ATEX introduced dust classifications for equipment (shown in the third column of the table below).

The required levels of dust protection are:

Zone IP	**Rating**	**ATEX category**
Zone 20	IP6X	1D
Zone 21	IP6X	1D or 2D
Zone 22	Non-conductive dusts IP5X Conductive dusts IP6X	1D, 2D or 3D

The "X" should be replaced by a number rating equivalent to the required liquid ingress protection for the area.

Note that equipment in areas such as silos may need to be specified for both dust and gas hazards as both dust laden atmospheres and flammable biomass decomposition products may be present.

A full discussion of the application of DSEAR to the biomass industry is unfortunately outside the scope of this paper, however, it should be noted that compliance with DSEAR is key to maintaining the safety of any biomass system, regardless of how large or small, from fire and explosion hazards. Specialist advice should be sought from persons or companies having experience of DSEAR and in DSEAR for particular biomass systems in the design of any new facility at an early stage of the design process. Experience has shown that trying to “bolt on” DSEAR compliance to an existing facility is always expensive and often not completely effective.

Specification of ATEX equipment requires knowledge of the type of atmosphere and the flammability characteristics of the material. This will allow for specification of the Gas Group (relating to spark ignition hazard) and Temperature Class (maximum surface temperature of the equipment) and zone rating which will be needed if the correct equipment is to be installed.

Note that it will be found that virtually all gas detection systems are ATEX certified as is required by the potential for detection of flammable gases.

Learning from Experience

The use of bulk biomass for fuel use is relatively new within the UK, however, the risk of fires and explosions in other “biomass” materials e.g. food related products such as flour and grain storage had been well known and documented for many years. There is also extensive experience with biomass fuel applications in the USA and other EU countries.

From the wealth of experience of biomass installations both within the UK and other countries it should be clear that the hazards of biomass are sufficiently well understood to enable the design and operation of a safe system.

The late Trevor Kletz was a champion of learning from previous accidents and incidents and it is clear that that is exactly what the biomass industry needs to do in order to prevent further incidents.

Conclusions

Biomass is an inherently dangerous material possessing significant fire and explosion hazards. The increasing scale of biomass use brings several challenges, especially where the scale of installations significantly exceeds the scope of any previous installation in terms of size.

Compliance with current standards does not necessarily mean that the installation is “safe” and a risk based approach is required to ensure that the level of risk to personnel is reduced to a level that is As Low As Reasonably Practicable. In additional to the risks to personnel, there may be significant environmental risks related to fire fighting and the pollution effects arising from fire water run-off.

There are major challenges in several areas. Fire prevention & protection systems for very large installations may be problematic due to the sheer size of the potential fire. These also require careful design and installation if they are to operate correctly.

Explosion protection systems for large capacity silos is outside the range of volumes in current explosion relief correlations e.g. VDI 3673 [Ref.4] & BS EN 14491 [Ref.5] and careful design of explosion relief systems for large storage silos is needed. It is noted that CFD has been used for modelling of some large silo explosion relief installations, but this needs careful consideration with respect to the parameters used in the model.

The hazards from transport of biomass should not be under-estimated, particularly with respect to the potential for delivery of hot of burning materials in bulk deliveries.

The failure of the wider biomass industry to learn from previous accidents and incidents is noted, and it is considered that further incidents are inevitable given the lack of understanding that biomass is a hazardous material. The expansion in the size of storage facilities offers several challenges in the areas of design of fire protection systems and also in the emergency response to incidents of this scale.

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