PROJECT : **Sleaford Renewable Energy Plant**
DATE : 2016.10.27
ISSUED BY : RBBD APPROVED BY: LSE
SUBJECT : **Dangerous Substances and Explosive Atmospheres (DSEAR)**

QHSE TECHNICAL REPORT

Table of Contents

QHSE TECHNICAL REPORT

1. Report Details

Locations Assessed	Sleaford Renewable Energy Plant
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Assessor(s)	Rinette Drewsen
Issue Date	27. October 2016

This DSEAR risk assessment deals mainly with dangerous substances in relation to explosion risk. Fire risk assessment is detailed in the document 2971.CS.020.000 Fire Safety Strategy Report.

2. Main Findings and recommendations

The assessment identifies dust from straw and wood fuel inside the vacuum cleaning system as the primary explosion hazard within the plant. The dust is concentrated within the vacuum cleaning filter unit where the lower explosion limit may be exceeded.

The vacuum suction lines and the dirty side of the filter are classified as EX zone 21. There are no obvious ignition sources within the zoned system, but the filter unit is fitted with a blast panel and a duct to guide any potential explosion out into the atmosphere above the building.

Dust can be carried in the air and may settle and accumulate on surfaces not commonly accessed. In the event that a layer of dry dust is abruptly disturbed, it may potentially form an explosive atmosphere with the air.

Procedures are therefore established to ensure regular cleaning of all affected areas to prevent build-up of dust layers.

3. Action Summary

Appropriate information, training and instructions shall be given to operating and service personnel regarding the proper precautions for ensuring a safe work environment on the power station.

Established procedures and work instructions for cleaning of straw and wood dust from exposed areas must be followed to ensure limited accumulation of wood dust.

4. Risk Assessment

4.1 Introduction

This risk assessment has been devised to meet the requirements of regulation 5 of the Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR).

Regulation 5 of DSEAR requires employers to:

1. Carry out a risk assessment of all current activities that may involve exposure to dangerous substances[1].
2. Not carry out any new work that may involve 'dangerous substances' unless a risk assessment has been carried out by a competent person.

This risk assessment has been devised to meet these requirements by:

1. identifying locations where dangerous substances are handled, used or stored;
2. identifying any significant hazards arising from handling, use or storage;

[1] Dangerous substances in the DSEAR regulations include any substance or preparation which, because of its properties or the way it is used, could cause harm to people from fires and explosions.

3. assessing risks and the adequacy of control measures (existing or proposed), and
4. identifying any remedial actions where necessary.

4.2 Scope

The scope of the assessment includes explosion hazards arising from the handling and storage of flammable substances in and around the workplace.

4.3 Methodology

The risk assessment is carried out by a 'lead' assessor in cooperation with project group members familiar with the work activities carried out in the area(s) being assessed. The assessment team carries out a 'walk-through' survey of the area to identify and examine work activities and the workplace conditions. The purpose of the walk-through survey is to gather all necessary information for identifying potential hazards and assessing risks.

The result of the risk assessment is enclosed in Appendix A.

Remedial actions identified are listed in Section 3: **Action Summary**.

A list of the hazardous zones identified is given in Section 5: **Hazardous zones**.

5. Hazardous zones

As per the risk assessment, the following areas will be classified as hazardous zones:

- Aq. ammonia tank head space — EX zone 1
- Void between aq. ammonia tank double walls — EX zone 2
- One meter distance around aq. ammonia tank vent — EX zone 2
- One meter distance around aq. ammonia tank vacuum breaker — EX zone 2

- Aq. ammonia underground safe basin	EX zone 2
- One meter distance around aq. ammonia basin vent	EX zone 2
- Wood chip silos	EX zone 22
- Wood chip feeding system from silos to Inlet of stoker screw	EX zone 22
- Fuel feed chute(s)	EX zone 22
- Vacuum cleaner unit internals	EX zone 21

6. Hazardous area drawings

Hazardous area drawings are prepared, showing the identified ATEX zones as per this assessment:

2971.D2.001.801, 2971.D2.122.801, 2971.D2.622.801, 2971.D2.624.801, and 2971.D2.721.801.

Note that the plant has been prepared for potential future installation of natural gas to be used instead of diesel oil for the boiler start up burners. This has been taken into account when preparing the hazardous area drawings in order to avoid locating any equipment constituting a potential ignition source close to the potential future gas installation. However, a detailed risk assessment of the potential gas installation has not been carried out.

7. Signs

The identified ATEX zones as per this assessment have been marked by proper signs.

8. Personal Protective Equipment

Dust mask and closed goggles are required where work is carried out within an area where straw and wood dust is present. Under normal circumstances all

activity which generates or releases dust must be stopped for work to be carried out.

Signs informing about the required personal protective equipment are posted at all relevant access points.

9. Instruction and training

Training of employees shall ensure a general awareness of the potential fire and explosion hazards that exist on the power plant. Service and operational staff shall receive detailed instruction regarding the work related risks and safe work procedures that exist for the facility.

Procedures and work instructions have been established to ensure safe operation of the plant. This includes procedures for cleaning of straw and wood dust from exposed areas to ensure limited accumulation of wood dust and procedures for safe handling of gas bottles.

External contractors that perform any work on the plant shall prior to commencement of the work receive information about the risks and safe work procedures relevant for the location(s) where they will be employed.

10. Emergency Procedures

Detailed emergency procedures for the entire power plant have been formulated. The procedure for formulation of emergency procedures included on-site inspection to ensure a proper overview of access ways and restrictions on site.

Appendix A: DSEAR Risk Assessment

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**1**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
Issued By:	RBBD	**Approved By:**	LSE	
Subject:	**DSEAR Risk Assessment**			

Substance:	**Baled and loose straw**
Substance properties:	Moisture content between 7.1% and 30%. Fraction of ignitable organic dust < 0.5 mm is expected very low. Straw dust is combustible and may potentially form an explosive atmosphere with air under unfavourable conditions. The lower explosive level for straw dust (particle size < 0.5 mm) is typically in the range 30-150 g/m3, depending on particle size and moisture content. A dust cloud of this concentration resembles a very dense fog with a visibility distance below a meter.
System description:	Main fuel for the power plant will be baled straw which is delivered to the plant by road vehicles. The bales will be transferred from the lorrys by overhead cranes placed in the straw barns. From the straw barns, the bales are transported on a chain-conveyor system to a bale opener and on to a fuel dosing bin before being fed into the boiler by means of feed screws.
Affected areas:	Straw barns, straw conveyors, straw feed lines.
Approx. quantity:	Approximate straw throughput is 30 t/h. Storage capacity in each of the two barns is 2160 bales (approx. 1000 tons) Limited dust quantity

Hazards	Causes	Control measures	Assessment
Dust explosion in straw barn.	Handling of baled straw in the straw barn will likely generate some loose straw and dust. Dust in high concentrations may form an explosive atmosphere.	Formation of an ignitable dust cloud is not considered likely due to low fraction of ignitable dust particles < 0.5 mm in the fuel and no processing of the straw. Regular cleaning of loose straw and dust to prevent build-up that may facilitate a fire.	Adequately Controlled
Dust explosion along the straw conveyors	Handling of straw bales may release dust. Suspended straw dust may form an explosive atmosphere if the dust concentration is sufficiently high and particle size and properties unfavourable.	Very limited dust generation as fuel is only transported at low velocity. No obvious ignition sources.	Adequately Controlled

Dust accumulation in straw barn	Dust from the straw is released during handling. The dust will be suspended in the air for a period of time and some of it may accumulate on horizontal surfaces away from the dust generating zone. A disturbance of an amount of accumulated dust may form a potentially explosive atmosphere which can be ignited.	The amount of dust released from handling of the straw bales is expected to be minimal, but the possibility exists for accumulation of dust in elevated/in-accessible locations. Procedures for regular cleaning of the barns and especially areas where dust may potentially settle will be established.	Adequately Controlled
Dust accumulation along the straw conveyors		The fuel storage building is designed to limit the possibility of dust accumulation in elevated locations as well as in areas e.g. beneath the conveyors where air circulation is minimal.	
Dust accumulation inside and around the straw conveyors			
Fuel Feeder lines and stoker chutes	In the fuel feeder lines the straw is loosened with the bale opener. The fuel feeder lines are airtight down from the seal gates to the furnace and higher dust concentrations inside of the fuel feeder lines are likely to occur during normal operation.	The fuel feeder lines are airtight down from the seal gates to the furnace and only slightly higher dust concentrations inside of the fuel feeder lines are likely to occur during normal operation – but from practical studies it is no match comparable to a dense cloud. This has been confirmed by photos/videos as well as dust measurements, ref. BWE document no. 13053-1500013 “ATEX Zone classification for straw and wood chips system”.Therefore, with regard to straw dust the inside of the fuel feeder lines from the seal gates to the water cooled stoker ducts are considered unclassified. (The stoker ducts from bale opener to inlet of stoker screw is classified as Zone 22 due to the risk of suspended wood chip dust from wood chip addition.)	Adequately Controlled

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**2**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
Issued By:	RBBD	**Approved By:**	LSE	
Subject:	**DSEAR Risk Assessment**			

Substance:	**Wood Chips**
Substance properties:	Moisture content between 20 and 55wt%. Limited fine fraction and a main fraction in the range 5 to 100 mm. The fuel must not be contaminated by chemicals added by man. Wood chip dust is combustible and may potentially form an explosive atmosphere with air under unfavourable conditions. The lower explosive level for wood dust (particle size < 0.5 mm) is typically in the range 30-150 g/m3, depending on particle size and moisture content. A dust cloud of this concentration resembles a very dense fog with a visibility distance below a meter.
System description:	Chipped wood fuel for the power plant will be delivered to the plant by road vehicles. The wood chips are unloaded onto a push floor. From the push floor fuel will be transferred by an enclosed conveyor system through an oversize separator and a magnetic and non-magnetic metal separator by an enclosed conveyor system to the fuel dosing bin in the boiler house.
Affected areas:	Fuel storage building, conveyors, boiler intermediate fuel bin
Approx. quantity:	Fuel storage building: 400 m3 Limited dust quantity

Hazards	Causes	Control measures	Assessment
Dust explosion in storage building.	Handling of dry chipped wood may release wood dust. Suspended wood dust may form an explosive atmosphere if the dust concentration is sufficiently high and particle size and properties unfavourable.	Formation of an ignitable dust cloud is not considered likely due to low fraction of ignitable dust particles < 0.5 mm in the fuel.	Adequately Controlled
Dust explosion in conveyors	Handling of dry chipped wood may release wood dust. Suspended wood dust may form an explosive atmosphere if the dust concentration is sufficiently high and particle size and properties unfavourable.	Very limited dust generation as fuel is only transported at low velocity and without significant falls. No obvious ignition sources.	Adequately Controlled
Dust explosion in wood chip silo or feeding line	Handling of dry chipped wood, especially when dropped to a free fall in a confined space, may release wood dust. Suspended wood dust may form an explosive atmosphere if the dust concentration is sufficiently high and particle size and properties unfavourable.	The internal of the wood chip silo and feeding line is classified as zone 22. No obvious ignition sources.	Adequately Controlled

Dust accumulation in storage area	Dust from chipped wood is released during handling of the material. The dust will be suspended in the air for a period of time and some of it may accumulate on horizontal surfaces away from the dust generating zone. A disturbance of an amount of accumulated dust may form a potentially explosive atmosphere which can be ignited.	The fuel storage building is designed to limit the possibility of dust accumulation in elevated/in-accessible locations. Procedures for regular vacuum cleaning of wood dust from areas where dust may potentially settle will be established.	Adequately Controlled
Dust accumulation around conveyors		Conveyors are fully enclosed to limit dust emission. Procedures for regular vacuum cleaning of wood dust from areas where dust may potentially settle will be established.	Adequately Controlled

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**3**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
Issued By:	RBBD	**Approved By:**	LSE	
Subject:	**DSEAR Risk Assessment**			

Substance:	**Dust in Vacuum Cleaner**
Substance properties:	Dust originating from Straw and Wood Chips
System description:	A central vacuum system is installed for collecting wood chip residuals and from cleaning around the boiler, conveyors and FGT equipment. Material from the vacuum cleaner filter will be collected in a bin/container for disposal or fed into the boiler.
Affected areas:	Vacuum cleaning system from straw barns, conveyors and fuel feeder lines. Vacuum cleaning filter.
Approx. quantity:	Limited dust quantity

Hazards	Causes	Control measures	Assessment
Explosion in vacuum cleaner system	During operation of the vacuum cleaner system, the system may potentially contain ignitable dust in sufficiently high concentrations to form an explosive atmosphere inside the suction line or the container.	The internal volume of the vacuum cleaner dust container and suction lines are classified as zone 21. Rupture disc on filter unit for safe pressure release in case of explosion.	Adequately Controlled

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**4**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
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Subject:	**DSEAR Risk Assessment**			

Substance:	**Diesel oil**
Substance properties	Industrial Gas Oil in accordance with BS 2869:2010+A1:2011, class A2 or D. Flash point of minimum 56°C. Typical auto-ignition temperature of 210°C
System description:	Diesel oil is used for the boiler auxiliary burners, the diesel oil filling station, the diesel driven fire pump and the emergency generator. The diesel oil storage tank will be constructed as a vertical cylindrical steel tank with fixed roof and vent to atmosphere. The tank will be located within a bunded area. Diesel oil is delivered by truck. From the oil tank a supply pump unit is transferring the oil to an oil circulation unit of the burner. Oil is returning to the oil storage tank from the burner oil circulation line. The diesel oil filling station, diesel driven pump and the emergency generator are furnished with their own diesel oil tanks.
Affected areas:	Diesel storage tank, diesel transfer pipe system, boiler support and start-up burners. Diesel oil filling station, diesel oil tanks for diesel driven fire pump and emergency generator.
Approx. quantity:	45 m3

Hazards	Causes	Control measures	Assessment
Explosion in diesel oil tank	The volume above the liquid level inside the tank will contain hydrocarbon vapours. Vapour inside of storage tank may mix with air to form an explosive atmosphere.	Diesel oil is stored and handled below its flash point temperature. An ignitable mixture in air is therefore not foreseen under any normal conditions.	Adequately Controlled
Explosion at tank vent	Vapour from inside the tank may flow through the tank venting pipe during filling of the tank and form an explosive atmosphere with air near the vent opening.	Diesel oil is stored and handled below its flash point temperature. An ignitable mixture in air is therefore not foreseen under any normal conditions.	Adequately Controlled

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**6**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
Issued By:	RBBD	**Approved By:**	LSE	
Subject:	**DSEAR Risk Assessment**			

Substance:	**Hydrogen**
Substance properties:	Lower explosive limit of 4 vol% and upper explosive limit of 75 vol%
System description:	For monitoring of the flue gas emissions a Continuous Emission Monitoring System (CEMS) will be installed in the stack. The CEMS uses fuel gas (H2/He mixture) and calibration gases, which may be flammable. The calibration gas bottles and fuel gas bottles are located outdoor in separate open vented cages. The gas is fed through hoses/pipes and is used for calibration of measurement sensors located inside a shelter unit.
Affected areas:	CEMS house
Approx. quantity:	Potentially up to 50 kg

Hazards	**Causes**	**Control measures**	**Assessment**
Gas explosion in outside gas cage	In the event of a gas leak the gas may form an explosive atmosphere if mixed with air to within the lower/upper explosive limits.	The risk of significant leakage from the gas bottles is considered to be very low and the bottles are located outdoor in a well ventilated area. The risk of creating an explosive gas atmosphere is therefore considered negligible.	Adequately Controlled
Gas explosion in CEMS house	Accumulation of gas from leaking equipment may form an explosive atmosphere inside the CEMS house	The CEMS house has redundant monitored ventilation system and is equipped with a gas detector which will shut off supply of gas in the event of gas detection.	Adequately Controlled
Explosion of gas cylinder	Heating of the gas cylinders due to an external fire	Procedures will prescribe that in the event of a fire, the cylinders must be cooled and/or evacuated to a safe location. Signs will be posted to show location of gas cylinders.	Adequately Controlled

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**7**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
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Subject:	**DSEAR Risk Assessment**			

Substance:	**Hydrogen**
Substance properties:	Lower explosive limit of 4 vol% and upper explosive limit of 75 vol%
System description:	The UPS (uninterruptable power supplies) and DC systems are supplied by batteries, located in the Battery room. Small amounts of hydrogen gas are released during charging of the batteries.
Affected areas:	Battery room
Approx. quantity:	

Hazards	Causes	Control measures	Assessment
Gas explosion in battery room	Accumulation of hydrogen in the room caused by insufficient or failed ventilation and formation of an explosive mixture with air.	To maintain the hydrogen concentration below the lower explosive limit the room is subject to monitored ventilation (redundant fans) with a minimum air exchange rate specified according to EN 50272 (2001). In case of failure on both ventilators, the operators will be notified and charging of the batteries will be suspended after a pre-defined period.	Adequately Controlled

Project:	**Sleaford Renewable Energy Plant**			
Project no.:	**2971**	**S0.X02.001**	**8**	**Appendix A:DSEAR Risk Assessment**
	Proj.	DOC.NO.	sheet	title
Date:	2016-10-27	**Rev.:**	3	
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Subject:	**DSEAR Risk Assessment**			

Substance:	**Aqueous Ammonia, 25% solution**
Substance properties:	Aqueous ammonia is not classified as flammable. However, ammonia vapours will evaporate from the ammonia solution and if mixed with air in confined spaces it may form an explosive atmosphere. The flammable range of ammonia in air is 15-28 vol%.
System description:	Aqueous ammonia is used in the boiler SNCR system and in the SCR plant for reducing NOx emissions. In addition, aq. ammonia is used for conditioning of the boiler feed water. The aq. ammonia (25%) storage tank is a 35 m3 double wall tank located in the flue gas treatment area. The tank is equipped with leak detection in the void between the tank walls and ammonia vapour detection is installed in the storage tank area and filling area. To prevent discharge of ammonia vapours to the atmosphere during filling of the tank, the tank is equipped with a gas return system which returns displaced gas to the tanker. Drain from the unloading area is connected to an underground safe basin which is designed to contain the volume of a tanker in case of a major spillage. The tank is located outside for good ventilation. The mixing and metering cabinet at boiler where vapour can form in case of leaks is also equipped with ammonia vapour detector.
Affected areas:	Tank location, transfer piping, SNCR system, SCR system.
Approx. quantity:	35 m3

Hazards	Causes	Control measures	Assessment
Tank head space	In the tank head space ammonia vapours will be present.	Depending on the temperature, an explosive atmosphere may form in the tank head space. The tank head space is therefore classified as EX zone 1.	Adequately Controlled
Void between tank double walls	Leak of ammonia to the void	Ammonia will not normally be present in the void between the double walls, only in case of leakage of the inner tank. The void is therefore classified as EX zone 2.	Adequately Controlled
Pipelines and transfer equipment	Leak of ammonia	The aq. ammonia pipelines and transfer equipment outdoor or in well ventilated areas are considered unclassified. The risk of creating explosive mixtures with air in case of leakage is minimal and considered negligible when ventilation conditions are good. Aq. ammonia pipelines in the boiler building and the turbine building is considered to be in well ventilated areas.	Adequately Controlled
Underground safe basin	Spill during unloading or leak	Aq. ammonia will be present in the underground safe basin only in case of a major leakage during unloading of a tanker. The underground safe basin and an area within 1 m distance from the tank breathing vent are classified as EX zone 2.	Adequately Controlled