Note

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from:	ir. N.J. van Oerle
to:	NUON, mr Marinus Hartman

1 Introduction

Peutz bv has been commissioned by NUON to perform calculations of the heat radiation emerging from a fire with wood pellets. The wood pellets are used as fuel for the production of heat, and are stored in cylindrical silo's with an effective height of approx 20 m, and a diameter of 9 m.

The question is whether a fire in one or more silo's filled with wood pellets can spread/extend to a nearby building through heat radiation from the fire and the flames. In this project, the scenario of a fire in a truck (loaded with wood pellets) close to a building was investigated also.

Radiant heat (source)

The heat emerging from a fire of a large pile of wood pellets can be measured with a medium scale fire test in a laboratory. Without a test, a (conservative) estimate has to be made about the intensity of the heat radiation emerging from the fire of a large pile of wood pellets, based on 'standard' calculation models.

Two calculation methods are available to calculate the radiation levels from the fire, and the radiation level received by nearby buildings, the NEN 6068 and the Infomil calculation model. These models are described below. In the next chapter calculations have been made with both calculation models for the scenario of a fire in a silo, in open air after collapse of a silo, and a fire in a truck loaded with pellets.

Size of the fire

The size of the fire and flames for the fire in a pile of wood pellets has to be estimated. If the fire occurs inside a silo, the assumption can be made that the radiant size of the fire is not larger than the actual silo. After collapse of a silo, the size of the pile must be estimated. The calculations have been performed for various sizes of the resulting pile.
It is assumed that precautions have been taken that a collapsing silo will not drag more than one other silo, preventing a domino effect with a very large fire size and a complete loss of the storage facility.

The calculated sizes of pile include the failure of one or two silos, resulting in a pile of considerable size. This approach is taken since little information is available on the failure of silos, and can be considered as conservative.

NEN 6068

In the Dutch Building Codes a calculation model is described in the NEN 6068 for fires in buildings. With this model the safe distance between the building on fire and an adjacent building can be calculated. The safe distance is defined as the required distance to limit the risk of fire spread to a low/acceptable level. In the NEN 6068 model, a calculated radiation intensity of 15 kW/m^2 on a building is regarded as safe value. The formal maximum storage/building height that can be calculated with this model is 15 m.

This prescribed model (NEN 6068) in the regulations is meant for fires in (all kind of) buildings, including industrial buildings. The basic assumption is that a wall of the fire compartment fails, and the resulting heat radiates from the lower half of the original wall with a radiance intensity of 45 kW/m^2.

For this method, the minimum distance between the fire and a building is 5 m, since with a shorter distance, flame contact could occur, resulting in a much higher risk of spread of fire.

The model is 'fitted' to situations where the external cladding of buildings complies with fire safety regulations in the Building Codes, so will be able to sustain the radiation of 15 kW/m2 for a considerable amount of time. In the circumstances with 'better' external cladding (for example a steel panel with mineral wool insulation) a considerable higher radiation level can be sustained without spread of fire.

Infomil

The other calculation model specified by Dutch government (Infomil) is specifically meant for the calculation of radiation evolving from fires in stacked wood, e.g. stacks of euro-pallets. This model is meant as a guidance, but the calculation model is not referred to from Building Codes; this model is often used during the procedure for a building/environment permit for storage areas of wood pallets. This model can also be used for densely stacked wood storage in silos or in open air (after failure of a silo) as present at the NUON plant. For this model a radiative intensity of 15 kW/m^2 on a building is regarded as safe value, conform the assumption in the NEN 6068.
The maximum storage height of the stack/pile that can be calculated with this Infomil model is 15 m, which is fixed in the calculation model. In this model a formal limit is included regarding the distance between the fire and a building of 5 m. This method could also be used for a fire in a truck loaded with (densely stacked) pellets present at the NUON plant.

2 Calculations

2.1 Introduction

For the storage of pellets (in silo and open air) and for a fire in a truck filled with pellets calculations have been done to determine the safe distance between the (side of) the fire, and a nearby building.

2.1.1 Infomil

This Infomil calculation model is supplied by the government for the calculation of the radiative energy emerging from stacked wood completely involved in fire.
There is a distinction between loosely stacked wood (for example stacked euro-pallets) with large ventilation gaps between layers and 'densely' stacked wood products for example a pile of wooden planks; therefore the calculations have been performed using the 'densely' stacked option (more realistic radiative values and flame heights).

Safe distance [m] for various dimensions of the size of the stacked pellets

Open air storage

Stack size		
Width [m]	Height [m]	Safe distance [m] (Q_{rad} = 15 kW/m^2)
20	15	14,5
20	10	11,5
15	15	12,5
15	10	10,5
10	15	9,8
10	10	8,5
9	15	9,2
9	10	8
9	5	5,8
5	5	5,1

Enclosed storage (silo)

Fire size		
Width [m]	Height [m]	Safe distance [m] (Q_{rad} = 15 kW/m^2)
9 (one silo)	15	9,2
21 (two silos)	15	14,0

Truck fire

Fire size		
Size [m]	Height [m]	Safe distance [m] (Q_{rad} = 15 kW/m^2)
truck 12 m (side)	4	5,8
truck 4 m (front)	4	5

2.1.2 NEN 6068 "industry model"

Silo fire (fully involved, enclosed fire)

Stack size		
Width [m]	Height [m][1]	Safe distance [m] (Q_{rad} = 15 kW/m^2)
21 (two silo scenario)	20	11
9 (one silo scenario, fully inv.)	20	7,6
9 (realistic silo scenario)	10	5,2

1 The height of the building/pile; the radiative surface (45 kW/m^2) is half this size.

3 Conclusions

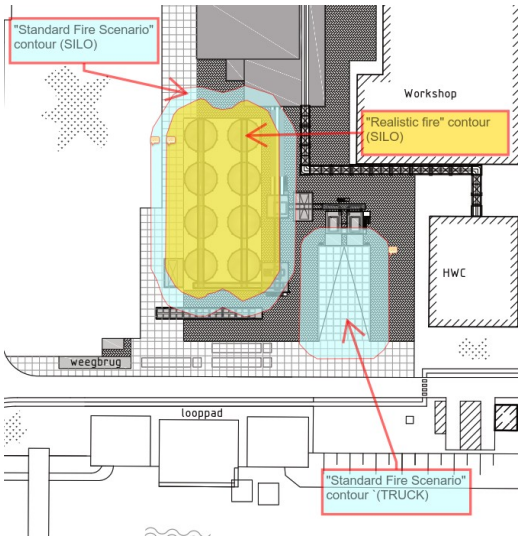
Calculations have been performed to obtain the safe distance from burning objects, like one or more silos and a truck filled with wood pellets.

The fire scenarios used for the calculations are based on standard calculation models given in Dutch regulations and building codes. These scenarios are based on fully involved fires in densily stacked wood or equivalent. In the scenarios, the flame height, en radiative power emitted from the fire are prescribed; the values are based on fire tests on stacked wood.

The “safe distance” from a fire is defined as the distance from the perimeter of the fire, where the level of incident heat radiation falls to 15 kW/m^2.

For standard building constructions with windows, this level of calculated radiation leads to an acceptable low risk of spread of fire to that building, according to Dutch building codes.

A building with 'better' than standard external cladding (for example a steel panel with mineral wool insulation, without openings/windows) a considerable higher radiation level can be sustained without spread of fire to that building.



In the picture above, an indication of the calculated 'safe' contours is given on a plan of the factory, both for a one-silo fire and a fire in a truck.
For the fire in one silo, two contours are given: the standard fire contour (assuming a closed silo, fully involved in fire resulting in a safe distance of 9,2 m), and the 'realistic' fire contour (resulting in a safe distance of 5,2 m). For the truck fire, the contour for a safe distance of 5,2 m is indicated in the picture.

Given the more favourable fire behaviour of the wood pellets used by NUON to be expected, these scenario's can be considered as very conservative (safe) estimates of the fire scenario and the resulting safe distances [2].

Mook,

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2 With a medium scale fire test, a more accurate etsimate of the fire scenario could be obtained.