P.O. Box 554 - 2665 ZN Bleiswijk
Brandpuntlaan Zuid 16 - 2665 NZ Bleiswijk
The Netherlands
+31 88 3473 723
nederland@efectis.com

REPORT

Analysis of fire spread Kloek Pallets, Kampen, The Netherlands

Report no.	2014-Efectis-R0105.119
Sponsor	Kingspan Insulation Lingewei 8 4004 LL TIEL
Author(s)	M.P. de Feijter B.Be. A.D. Lemaire M.Sc.
Project number	2014105/119
Date of issue	June 2014
Number of pages	17

CONTENTS

1. INTRODUCTION

On June 8th 2013, a fire started in Kloek Pallet factory at the Eckert street, Kampen, The Netherlands. Due to radiation of heat from the large fire, the roof of Asia Express food, Kilbystraat, Kampen, caught fire. The fire did not spread over the roof of the Asia building.

The roof of the Asia building was insulated with 65 mm PIR foam from Kingspan Insulation. Efectis Netherlands BV was asked by Kingspan Insulation to analyse the fire spread between the two buildings to determine the impact of the fire on the Kingspan insulation boards.

In this report a description of the fire load, the fire and the building is given.

1.1 METHOD OF INVESTIGATION

To analyse the fire the following information was obtained:

- photo and video footage obtained from;
  - Stefan Verkerk Fotografie en Webdesign;
  - Sjoerd van der Wal Fotografie;
  - E. Driessen, zelfvliegen.nl;
  - Kampen fire department;
- Visit at the site including an inspection of the roof of the Asia building;
- Interview with a member of the Kampen fire department;
- Documentation provided by Kingspan Insulation.

Based on photo and video footage the intensity of the fire is estimated. Based on the intensity of the fire, the heat flux and the surface temperature on the roof of the Asia building are estimated.

2. SITUATION BEFORE THE FIRE

2.1 SITUATION AND DIMENSIONS

On the premises of Kloek Pallets, pallets were stacked up to 5 m high (stacks of ±35 Euro pallets) over a surface of 100 m wide and 92 m deep. The distance between the fence of the Kloek premises and the Asia building is 24 m.

The Asia building is (on the side of Kloek pallets) 110m wide and 14 m high. Figures 1 and 2 give an impression of the situation.

Figure 1 Situation (source: Bing maps)

The (flat) roof of the Asia building consists of a steel deck, vapour barrier, Thermaroof TR26 FM / LPC (Rigid PIR foam) with a thickness of 65 mm and a Rhenofol CV 1,2 mm roof covering.

2.2 RULES ABOUT FIRE SPREAD IN THE DUTCH BUILDING AND ENVIRONMENTAL CODE

Buildings must be separated by a 60 minutes fire resistant construction (Bouwbesluit 2012). The needed fire resistance of the building is determined based on a symmetrical placed building on the other side of the premises border. In this case the centre line of the public road. The Asia building is placed on a distance of 20 m of the centre line of the road. So the fire resistance is determined based on a distance of 40 m. The stack of pallets is placed on a distance of 24 m from the Asia building.

The fire safety rules for stacking pallets on a premises are given as a guideline in the VROM publication “Bepalingsmethode warmtestralingsbelasting opslag van hout”. The prevention of fire spread from the stack to the adjacent premises is based on a maximum heat flux of 15 kW/m^2 on the face of the building. This heat flux can be calculated based on the dimensions of the pallet stack. An example is given in figure 3. This example uses the Infomil software that is used by the local government of the city of Kampen to check the required distance between the pallet stack and the building. Based on this calculation the fire should not be able to spread to the Asia building. However, based on calculations made by Efectis the

Infomil software seems to be limited to a maximum width of the stack of 37.5 m and cannot be used for a stack with a width of 100 m.

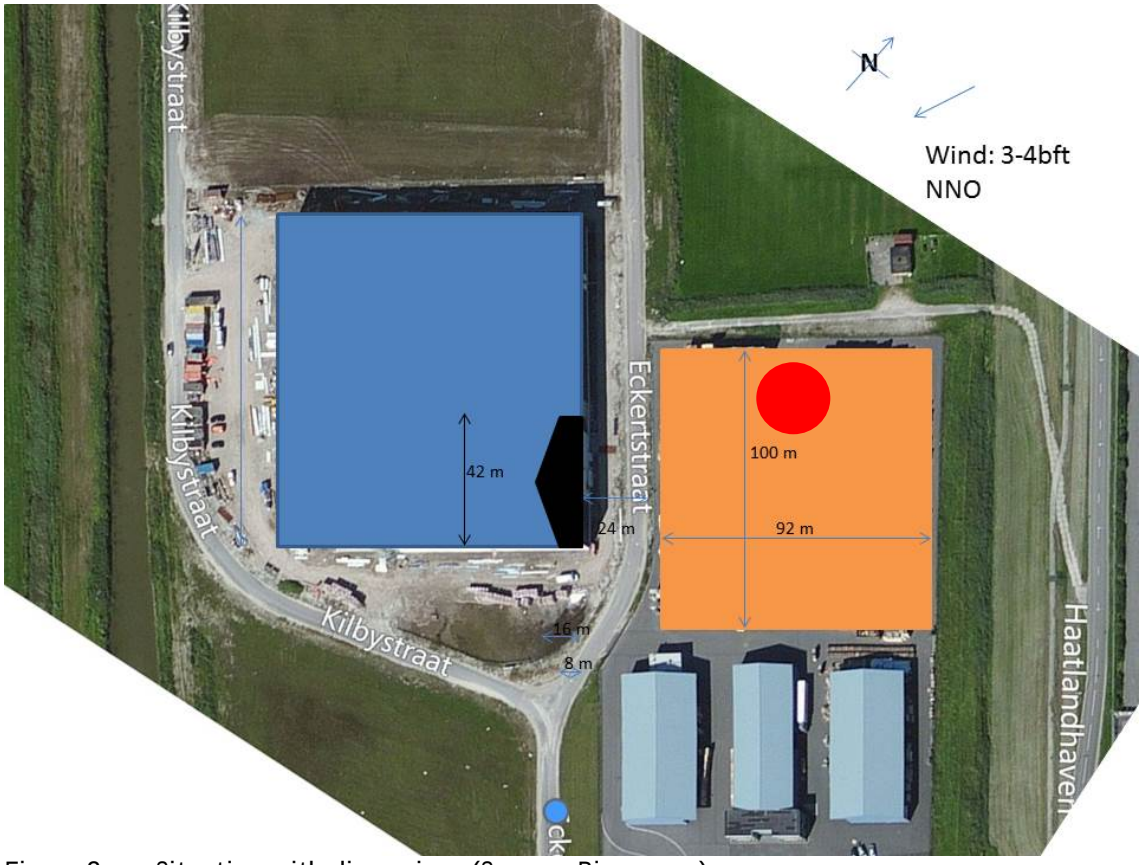

Figure 2 Situation with dimensions (Source: Bing maps)

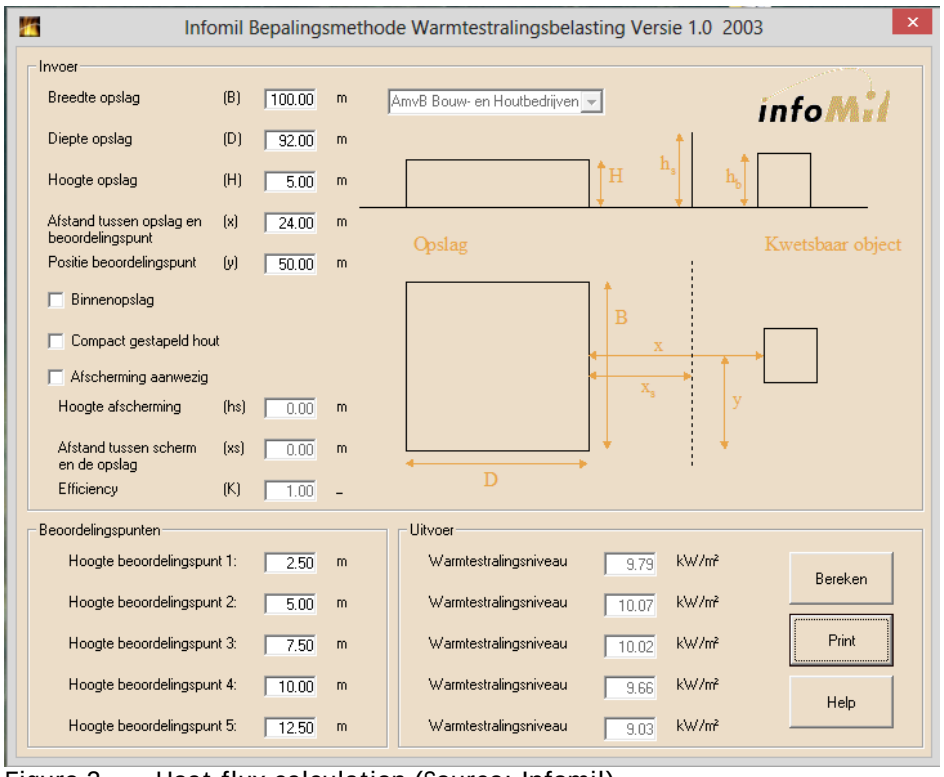

Figure 3 Heat flux calculation (Source: Infomil)

3. FIRE SIZE AND DURATION

The fire department was alarmed at 13:15:48h. After 1 minute the alarm was raised to "middle", 8 minutes later the alarm was raised to "large" and 14 minutes later to "very large". One of the first pictures was posted on the internet at 13:26h (figure 4).
The position of this first fire in the pallet stack is represented by the red dot in figure 2. The picture is taken from the side of the "Haatlandhaven".

Figure 4 One of the first pictures posted on the internet[1] at 13:26h

The two photo series that were obtained from two "fire photographers" start around 13:38h. At this time the fire has reached the edge of the pallet stack at the side of the Asia building.

Figure 5 Picture from the side of the "Haatlandhaven" at 13:38h (Source: Stefan Verkerk Fotografie en Webdesign)

[1] http://www.hulpverleningsforum.nl/index.php?topic=75608.0

In figure 5 and 6 the size of the fire seems to be doubled around 13:39h.

Figure 6 The size of the fire on the side of the Asia building at 13:39h (Source: Sjoerd van der Wal Fotografie)

The height of the flame varies in time. Based on the photo's the average flame height is determined around 31 m (from the underside of the pallet stack). The pictures show that flames were as high as 45 m perpendicular to the ground. Flame length exceeded 50 m (Figure 7)

Figure 7 Flame length of up to 51m (Source: Sjoerd van der Wal Fotografie)

Due to the wind (3-4bft NNE) the flame was pushed over the Asia building. The average angle of the flame was approximately 18° of the normal (72° from the ground).

At 13:44h smoke is coming from the roof of the Asia building (figure 8) and at 13:48h flames are visible on the roof (figure 9).

Figure 8 At 13:44h smoke is coming from the roof of the Asia building (Source: Sjoerd van der Wal Fotografie)

Figure 9 At 13:48h flames are visible on the roof of the Asia building (Source: Sjoerd van der Wal Fotografie)

At the moment the fire has spread to the roof of the Asia building the whole side of the pallet stack facing the Asia building was involved.

At 13:59h no more flames or smoke were visible on the roof of the Asia building. The fire department did not fight the fire on the roof because of the high heat flux[2].
After the fire, the roof of the Asia building was damaged by the fire. The size of the fire and the impact on the roof are depicted in the aerial photo in figure 10.

Figure 10 Aerial photo of the fire and the damaged roof on the Asia building (Source: E. Driessen, zelfvliegen.nl)

[2] Source: Kampen fire department

4. ESTIMATED HEAT FLUX AND ROOF SURFACE TEMPERATURE

Based on the information given in chapter 3 the size of the fire and the average flame height were determined. The estimated size of the fire is depicted in figures 11 and 12.

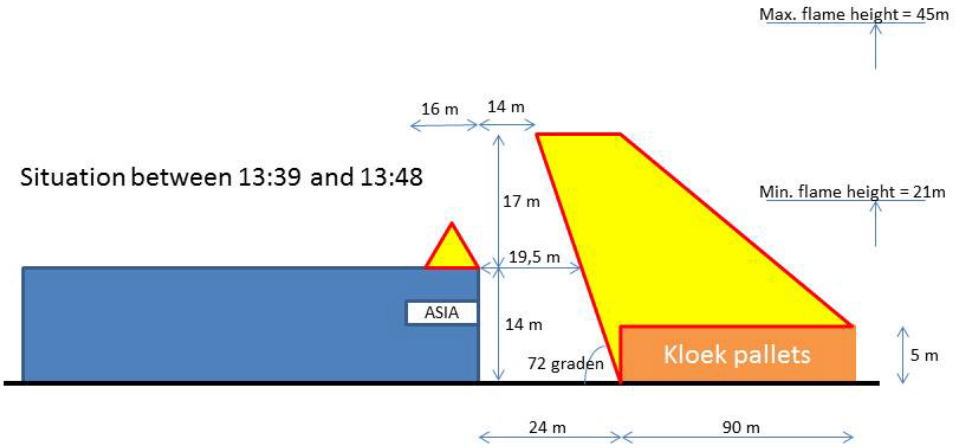

Figure 11 Fire size related to the size of the building

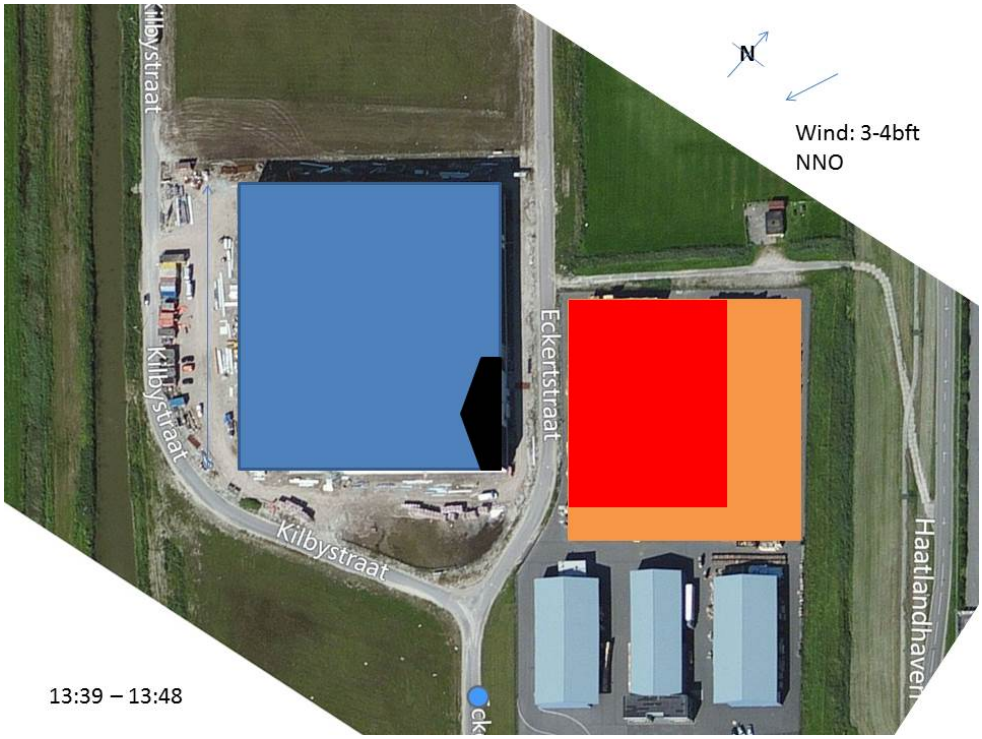

Figure 12 Estimated fire size at the time smoke was coming from the roof of the Asia building

To estimate the heat flux on the roof, calculations were made using "Shadow" software based on the pre-determined flame geometry. The radiant flame is modelled as a rectangular surface with a width of 96 m, tilted with an angle of 72°w.r.t to the ground . The horizontal distance of the base of the surface to the roof of the virtual Asia building is 24 m. (See figure 11). For calculation purposes the emission of the flame front is presumed to be uniform (radiant heat flux).

Three variations are calculated, varying in flame height and level of radiant heat flux:

Case 1: radiant heat flux 75 kW/m^2, compares to a flame temperature of 800 ^{o}C and a flame height of 31 m (average flame size during the fire).

Case 2: radiant heat flux 100 kW/m^2), compares to a flame temperature of 879 ^{o}C and a flame height of 31 m (average flame size during the fire).

Case 3: radiant heat flux 75 kW/m^2, compares to a flame temperature of 800 ^{o}C and a flame height of 45 m (highest flame as seen in the photo's).

The cases can be qualified as:

- Case 1: average
- Case 2: average-high
- Case 3: high

Figure 13 shows the estimated heat flux on the surface of the roof. Figure 14 shows the estimated temperature on the roof. The temperature is calculated based on an estimated air temperature[3] of 30°C and an average wind speed of 5 m/s.

[3] The maximum temperature was around 19°C. It was a sunny day. The temperature above the roof of the Asia building is probably higher due to the fire (Source: www.knmi.nl).

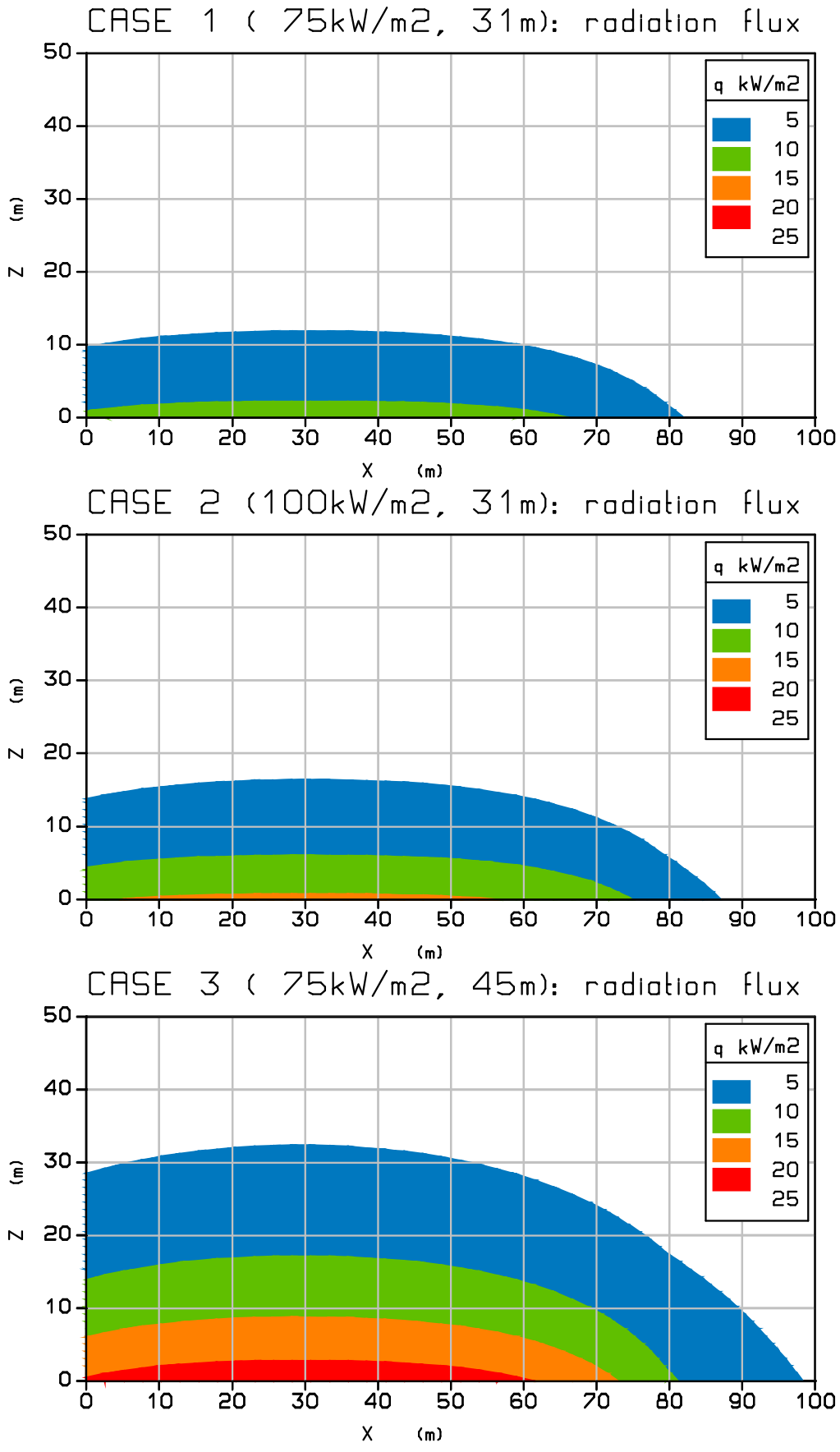

Figure 13 Calculated radiant heat flux on the roof of the virtual Asia building

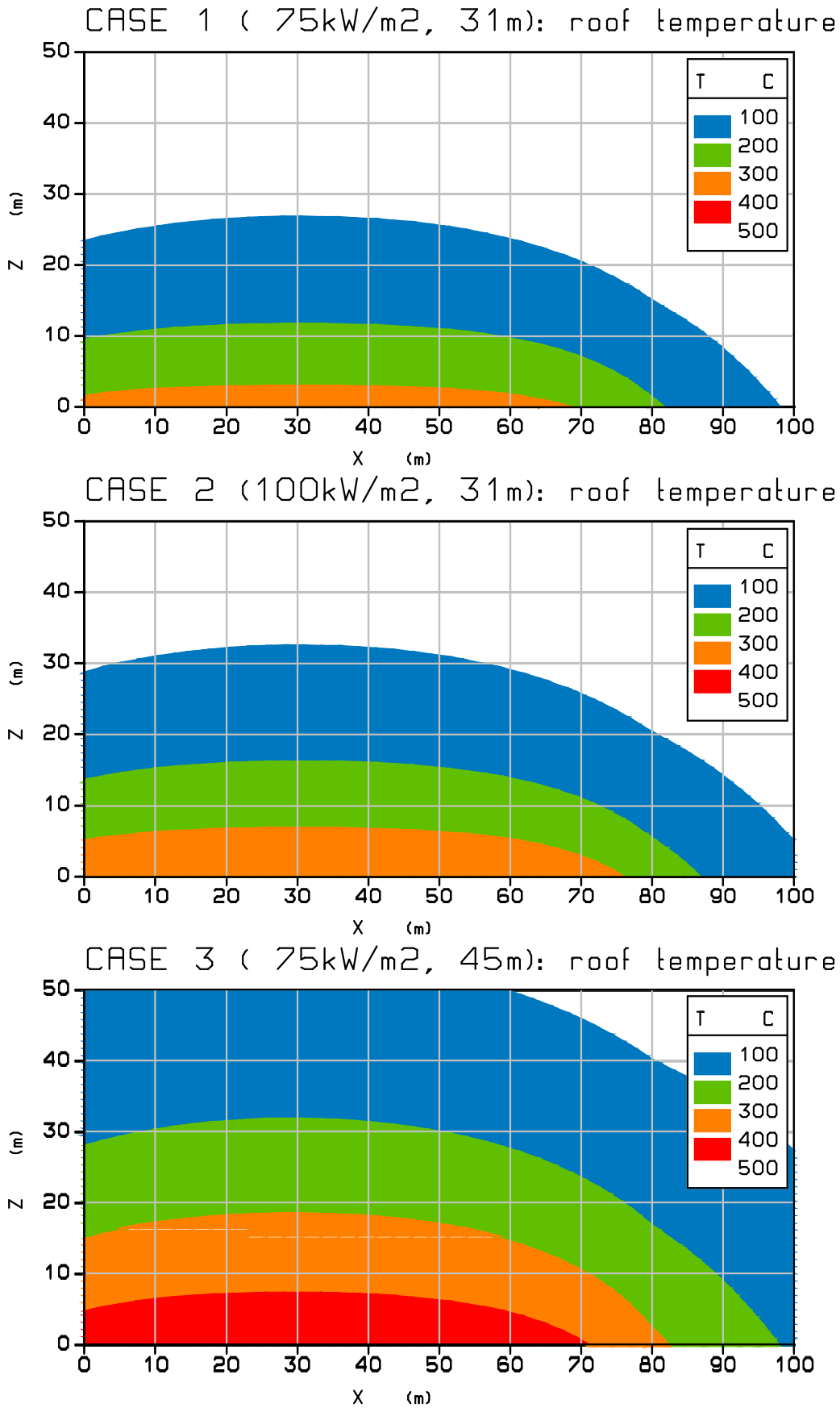

Figure 14 Roof surface temperature on the virtual Asia building

5. CALCULATIONS COMPARED TO THE DAMAGE ON THE ROOF

5.1 DAMAGE TO THE ROOF

The damage on the roof is visible in figure 15. Figure 16 gives a close up impression of the damaged roof. The size of the damaged area is estimated based on the available photos and given in figure 2 (chapter 2).

Figure 15 Overview of the damage to the roof (Source: Kampen fire department)

Figure 16 Damage to the roof of the Asia building (Source: Kampen fire department)

As stated the roof was made of a steel deck, a vapour barrier, a 65 mm insulation and a Rhenofol CV 1,2 mm (PVC-P) roof covering. PVC has a piloted ignition temperature between 320 – 440°C[4], depending on the composition of the PVC. A flexible roof covering has a lower ignition temperature than a rigid PVC product. Ignition can be piloted by flying embers from the pallet fire.
PVC can ignite at a heat flux of 15 kW/m^2 (piloted ignition).

The pictures show that the PVC roof covering was ignited. Therefor it has to be subjected to a heat flux of at least 15 kW/m^2. The insulation will ignite after the PVC roof covering has burned away. Compared to the calculations in chapter 4 the scenarios 2 and 3 are possible. Based on the surface temperature all 3 scenarios are possible.

5.2 PROPERTIES OF THE INSULATION PRODUCT RELATED TO FIRE

The insulation product used on the roof of the Asia building (Thermaroof TR26 FM / LPC) is tested according to EN ISO 11925-2 and has an "E" classification according to EN 13501-1:2007.
Mounted on a steel deck the product is classified "B-S2-D0" according to EN 13501-1:2007. The fire exposed side is the steel deck side.
The Thermaroof insulation board is a FM approval Class 1 roof product and is LPC LPS1181 approved.
From tests at the Efectis Laboratory it is known that a PIR foam does char when heated. Due to this charring the product does not contribute much to the development of a fire. When the heat source is removed, after a while the foam will self-extinguish.

The Rhenofol CV 1,2 mm roof covering present was tested according to Dutch standard NEN 6063 and is supposed to resist fire spread due to flying embers alone.

5.3 BEHAVIOUR OF THE INSULATION PRODUCT DURING THE FIRE

Based on the pictures it is clear that the roof was on fire during a period of 11 minutes. The fire on the roof self-extinguished without intervention of the fire department. Photos show that the insulation product was charred and discoloured for less than half of the thickness of the insulation sheet (figure 17).

Figure 17 Charring and discolouration of the insulation (Source: Kingspan Insulation)

[4] Ignition Handbook, V. Babrauskas

Based on the photos it is safe to say that the fire died out when the heat flux level of the pallet fire diminished.

6. CONCLUSION

Based on the photos and calculations Efectis estimated the impact of the fire on the roof of the Asia Express Food building. In both case 2 and 3, as presented in chapter 4, the heat flux exceeds 15 kW/m^2. Surface temperatures rise to 300°C and higher. The shape of the heated area on the virtual roof fits the shape of the damage on the real roof. The width of the calculated heated area is larger than the width of the real damaged area. This can be explained by the uncertainty about and variation in the width, the height and the angle of the flames during the fire.

Based on literature and documentation it is estimated that for the fire to spread to the roof the heat flux on the roof should have been at least 15 kW/m^2. The PVC roof covering will ignite at a temperature varying between 320 and 440°C.

It does not seem likely that the fire spread to the roof has been caused by flying embers alone. Flying embers can be the cause of piloted ignition of the PVC roof covering after it has been heated due to the high heat flux from the fire.

The fire development on the roof stopped without fire department intervention. This means that the combination of the Kingspan Insulation Thermaroof TR26 FM / LPC insulation board and the Rhenofol CV 1,2 mm roof covering did not support further fire development. As soon as the heat flux from the pallet fire diminished the fire on the roof died out.

M.P. de Feijter B.Be, IAAI-FIT
Project leader fire investigation

A.D. Lemaire M.Sc.
Project leader Engineering