Fire in a warehouse covered with photovoltaic panels

12th January, 2010

Val-de-Reuil (Eure)

France

Fire
Warehousing
Photovoltaic panels
Property damage
Building works
Intervention constraints

THE FACILITIES INVOLVED

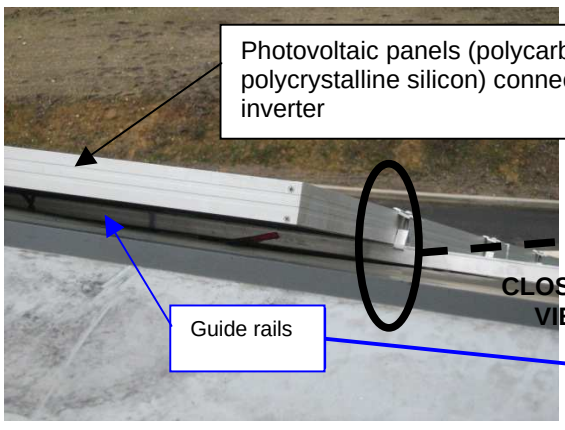
This warehouse facility was required to apply for authorisation under the "1510" heading of the nomenclature issued by the classified facilities inspectorate, in compliance with environmental protection measures. The facility comprised a total floor area of 15,000 m², composed of 3 cells juxtaposed by 2 office zones and a 1,000-m² utility building. An access road surrounded the complex. Inaugurated in November 2009, this logistics centre was awarded the HQE certification for outstanding environmental quality.

On two sides, the utility space abutted the warehouse, with separation provided by a 4-hour fire wall, and was built in breezeblock with a structural frame made of glued-laminated timber beams. Split into cells, this building also housed the installation used to operate the site's sprinkler system, as well as the post for recharging forklifts and the 37 inverters for the 660-photovoltaic panel installation occupying the building roof.

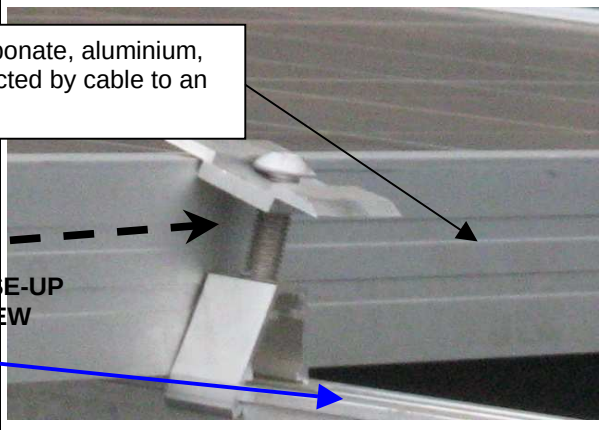
The industrial building and its roof composed of photovoltaic panels, prior to the accident - DR

The photovoltaic panels:

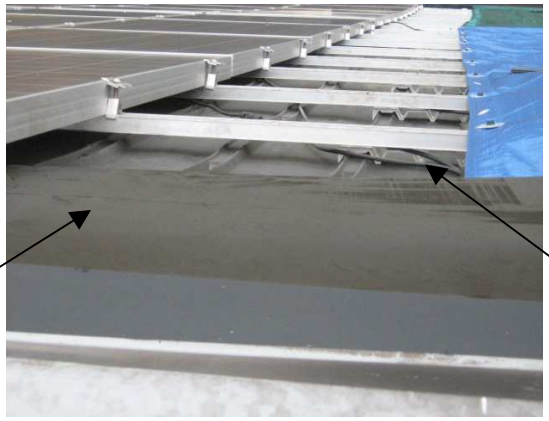
A layout embedded into the roof of the building streamlines the assembly of photovoltaic panels and allows for a perfect seal with the rest of the roof structure, via a system of guide rails and special anchors made of aluminium (see diagram on p. 2). This installation, at a price tag of €900,000, was able to output 132 MWh annually.



View of the photovoltaic panel assembly (source: DREAL)



Special aluminium anchors (source: DREAL)

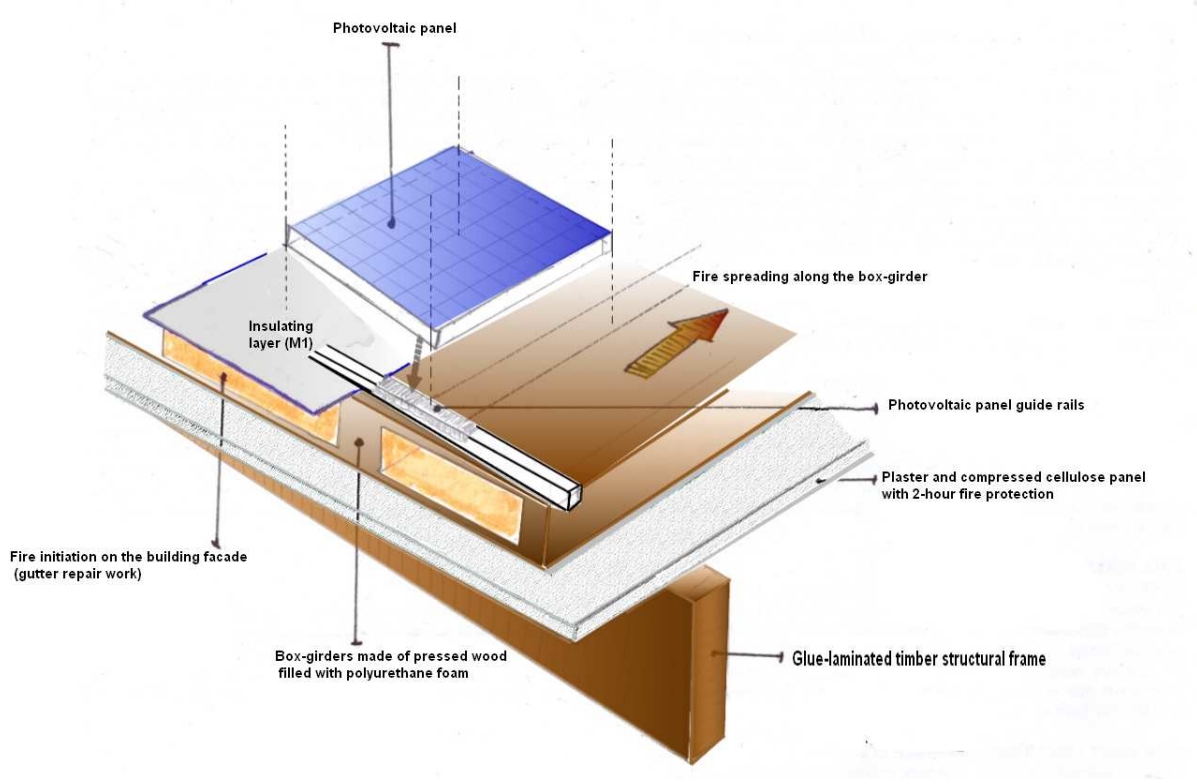


View of the sealed cables located underneath the photovoltaic panels (source: DREAL)

THE ACCIDENT, ITS CHRONOLOGY, EFFECTS AND CONSEQUENCES

Subsequent to repair works on a gutter at the utility building, fire broke out around 3 pm. Alerted at 3:14 pm, fire-fighters noticed a plume of smoke from their station. Upon arriving at the scene, the fire was burning over a 6-m² surface area occupied by photovoltaic panels and was following a trajectory along the roof slope towards the ridge line.

The fire source, located at the centre of the roof structure, threatened the entire surface of the photovoltaic panel display. Nozzles were deployed, yet these proved relatively inefficient, as the fire was spreading underneath the insulating layer within a wooden box-girder filled with foam.



Simplified diagram of the industrial building roof

Once fire-fighters had completed surveying the installations, the electricity supply was cut. Nonetheless, cables powered by residual voltage caused short-circuits beneath the photovoltaic panels. Since the fire continued to burn, emergency responders decided to disassemble the panels.

In conjunction with this effort, an opening was made in the roof ridge to insert a nozzle, making it possible to spray water under the layer of photovoltaic panels.

By 7 pm, the last panels located in the fire hazard zone had been removed. The fire could be extinguished 30 min later.

Given the risk that this fire would rekindle, the damaged roof was covered by a tarp and electrical circuits were isolated.

Covering of the damaged roof with a tarp (source: DREAL)

In all, 40 fire-fighters were called to the site to battle the blaze; their intervention would last nearly 6 hours.

From a practical standpoint, this emergency response was staggered over several stages:

- disassembly of 200 photovoltaic panels once the screwdriver kit with the appropriate bits had arrived;
- disassembly of the upper fire wall protective support separating the utility area from the storage cells, in order to access the space between the roof and the photovoltaic panels;
- sprinkling of the entire zone;
- installation of tarps to cover the roof before daybreak in order to prevent renewed fire outbreak.

Consequences of this accident:

This accident caused significant property damage and operating losses. The total amount was estimated at between €350,000 and €400,000. Moreover, the photovoltaic installation would be shut down for nearly 6 months, including a full month to disassemble all of the panels. The fire wound up destroying 1/3 of the total photovoltaic panel surface area.

Close-up of property damage (source: DREAL)

The European scale of industrial accidents:

By applying the rating rules applicable to the 18 parameters of the scale officially adopted in February 1994 by the Member States Competent Authority Committee for implementing the '*SEVESO*' directive on handling hazardous substances, and in light of information available, this accident can be characterised by the four following indices :

The parameters composing these indices and their corresponding rating protocol are available from the following Website: http://www.aria.developpement-durable.gouv.fr.

The "Economic consequences" index was scored a "1" because the amount of damages was appraised at nearly €400,000 ('€15 Property damage within the facility').

The "Hazardous substances released" index was not rated since none of the substances cited in Appendix 1 of the Seveso Directive were actually emitted, and moreover no explosion had occurred.

The "Human and social consequences" index was set equal to "0" since the accident resulted in no victims.

The "Environmental consequences" index was not scored due to the lack of data available on this indicator. Only a very small quantity of fire extinction water was actually used. Moreover, this water was never in direct contact with the panels since the fire had spread to the pressed wood box-girders.

THE ORIGIN, CAUSES AND CIRCUMSTANCES SURROUNDING THIS ACCIDENT

The causes of this fire outbreak were initially attributed to an electric arc that would have been produced when placing a metal part on the gutter. Nonetheless, when viewing the security video, it was in fact revealed that the subcontractor assigned to perform the gutter repairs arrived onsite with a flame source. These works were neither scheduled nor authorised by the warehouse operator.

Location of the exact spot where works took place (source: DREAL)

ACTIONS TAKEN

On 22nd January, the classified facilities inspectorate visited the site in order to collect information with the aim of compiling experience feedback specific to this incident. The inspectorate observed that the distance between the top of products stored in the warehouse and the roof base was less than 1 m, which reflects a noncompliance with respect to the Prefecture's operating permit. The pallets responsible for this noncompliance were immediately moved by management.

Regarding the photovoltaic installation, the inspectorate requested that the facility manager improve, in conjunction with the equipment installer, the layout in order to limit fire risks. Moreover, a protocol was to be written to facilitate the intervention of fire-fighters.

Subsequent to this accident, the operator made plans to install:

- a water pipeline fitted with nozzles, hooked up to the sprinkler supply, in order to generate a water stream under the photovoltaic panels within the zone made inaccessible in the event of fire;
- a system to drape tarps and covers in order to halt the production of electricity by means of occultation.

Nonetheless, given the difficulty involved in managing the problem of frozen water on the roof as well as the tarp surface to be deployed on the roof, the previous solutions were not selected in favour of a solution based on the principle of a general cut-out switch at the level of the inverters.

Handling of photovoltaic panels after the accident:

The panels damaged due to this accident could not be reused. This damage was revealed by:

- black traces caused by the fire (see photograph of property damage, p. 3);
- marks of hatchet or hammer strokes during removal attempts.

The unusable equipment was disposed of by a specialised subcontractor during an industrial waste treatment mission.

LESSONS LEARNT

The following difficulties were encountered by emergency services:

- acknowledgment of the eventual risk associated with electrification. With electricity supply cut to the installation, a residual direct current remained between the photovoltaic panels and the inverter. The voltage was estimated over a range from 100 to 300 V. This effect therefore was significant in an environment where fire-fighters were wearing wet protective gear. The direct current was also capable of causing muscle spasms;
- destruction of the insulating material in electrical cables, which was a source of short-circuits and additional fire outbreak sources;
- availability of panel disassembly equipment (electric screwdriver fitted with specific "anti-theft" bits);
- impossibility to stop electricity production from the panels, as the attempts at destruction proved ineffective until the screwdriver with proper bits was available onsite (resistance of photovoltaic panels to hammer blows);
- fire spreading into the space between the roof and the photovoltaic panels via cables and sealed cover, given that the cables and cover did not display non-combustible characteristics. The strong slope effect associated with this roof undoubtedly facilitated spreading of the fire;
- difficulties in accessing the box-girder of pressed wood (see diagram on p. 2) in order to extinguish the fire, as the photovoltaic panels were solidly fastened.

Nonetheless, the following technical systems helped avoid the fire from spreading to the remainder of the building:

- fire wall between the utility premises and storage cells;
- 2-hour fire-resistant panel composed of plaster and compressed cellulose underneath the photovoltaic structure (see diagram on p. 2).

Several solutions were mentioned in the specialised press to limit the risks associated with this type of installation, among which let's cite the following:

- harmonisation of the types of screws used during the installation step;
- use of non-combustible strips on the roof in order to contain the fire while awaiting panel disassembly;
- installation of dummy panels to facilitate access to concealed zones;
- the search for electricity production shutdown devices applicable to photovoltaic panels in the event of an accident (thermofusible, switch serving to short-circuit panels, etc.).

BIBLIOGRAPHY

"Risk prevention associated with the installation of photovoltaic cells on industrial buildings or buildings intended for use by individuals", *INERIS and CSTB*, December 2010; this publication can be downloaded from the following Web address: http://www.ineris.fr/centredoc/photovoltaique-web.pdf