

Study on fire performance of the insulation photovoltaic building components

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Abstract. The insulation photovoltaic Building component is a new kind of energy-saving building material with the function of heat insulation and new energy transformation. Because of combustible organic insulation materials and fire risk caused by control circuit fault, the fire performance must be concerned about. This paper studies the fire performance test for insulation photovoltaic Building component installed on building external wall, the development of heat release rate and total heat release are analyzed, compared with that of traditional organic insulation board. In addition the principle of fire test method for samples applied to building roof is introduced.

1、foreword

The fire risk of building insulation products have been paid wide attention recently, new building insulation products with higher thermal insulation function must have better fire safety performance simultaneously. However, the energy –saving effect relying solely on external insulation materials to reduce the energy exchange between inside and outside of the building is still very limited, new way must be introduced to the building energy-saving field, so that the heat insulation effect and new energy conversation mode can be achieved at the same time by building external construction.

Insulation photovoltaic building component is a set of building external structure with the function of energy conservation and solar energy conversation. The traditional building photovoltaic power generation system working mode is based on the external surface of the building, converting solar energy to electric energy by photovoltaic component . Photovoltaic power generation system is generally composed by the crystal silicon solar battery, controller, inverter and battery, the performance mode is illustrated in fig 1. Insulation photovoltaic building component is developed by integrating of external thermal insulation material based on the traditional photovoltaic power generation system. According to the different installation mode, Insulation photovoltaic building component can be divided into additional photovoltaic system (BAPV) and building integrated photovoltaic system (BIPV), BAPV is installed on the building external wall and roof after the basic construction completion, and BIPV system is designed as a part of building construction integrated with insulation material and photovoltaic power generation system.

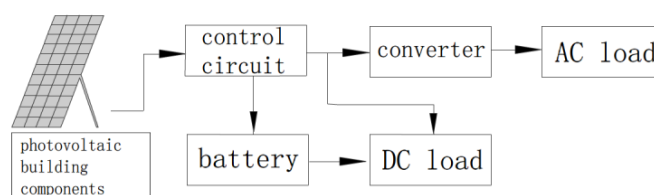


Fig 1 Photovoltaic power generation system operation mode

Because the external insulation material is integrated in photovoltaic power generation system, especially organic insulation is widely used, so the fire risk cannot be ignored. Because the organic insulation materials are included in the internal components, burning with a certain degree of

concealment easily caused late fire alarm, then best rescue time is deleted. In addition, the photovoltaic component contains internal circuit structure, possible high operation temperature can also ignite the insulation materials nearby when short circuit happens. Therefore, the fire performance research of insulation photovoltaic building component products also has very important significance.

2、Fire performance of insulation photovoltaic building components installed on the external construction wall

For the fire performance test of building material, test methods must be strictly designed on the basis of the real different appliance situation, combustion characteristics experimental data obtained under different test method cannot be compared directly. Installation mode is also needed to be considered for insulation photovoltaic building component products, so vertical combustion characteristic test method—single burning test(SBI) should be adopted to insulation photovoltaic building components installed on the construction external wall, while test method suitable for horizontal specimen should be adopted when fire performance of insulation photovoltaic building components installed on the building roof is concerned.

(1)single burning test (SBI)

Single combustion experiment (SBI) is the common evaluation test of building materials and products, a 30kW propane fire is used to ignite the sample at the intersection bottom of two vertical samples. According to the oxygen-consuming theory the real time heat release rate, total heat release and smoke generation is obtained by oxygen content change analyzing.

A domestic company product with dimension of 1200mm×600mm×40mm is adopted as test sample in this paper. A 10mm thickness PU insulation layer is enclosed in the sample. The main structure is shown in fig 2.

(2) Sample apparent burning phenomenon

After test, the whole sample structure remained intact, no obvious collapse phenomenon. The actual burning height of specimen surface is about 550mm, a 300mm x 100mm defect area is formed at the bottom of the vertical sample wings with the toughened glass and the battery board completely detached. Nonorganic board remained integrity, but the surface is cracking entirely, internal PU insulation is not exposed.

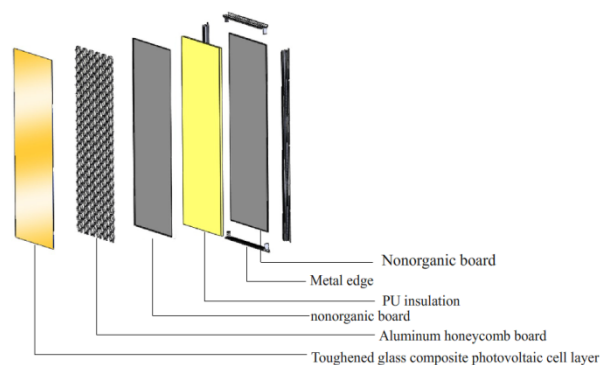


Fig 2: specimen main structure

After dismantling the specimen we found, a 400mm×200mm size of all or part of carbonization area was formed under the nonorganic board. This is because high temperature is formed which cause the PU carbonization through the nonorganic board, though no visible flame appeared, smoldering lasted for a very long time and release a lot of heat. Polyurethane material far away from the ignition source has little destroy degree. The PU insulation material only has a color change on the other position.

The author has conducted fire performance test of PU insulation board for several times, with the common 30mm thickness PU board as an example, the carbonization height can reach at list 1000mm and 300mm in the horizontal direction on the board surface after the test, and the flame penetrate the entire board. Compared with the status of insulation photovoltaic building components after burning test, it can be found that the carbonization area is obviously reduced than that of PU board. The possible reasons for this phenomenon is that with the protection of toughened glass、aluminum honeycomb board and nonorganic board, the destroy degree of PU insulation board enclosed in insulation photovoltaic building components is reduced significantly, and in the height direction, the upper flame energy is much lower than the flame root because of the air flow and flame instability, so the PU can be prevented form damage because the enough protection of the nonorganic board.

(3) Heat release performance analyze

The current building material classification system is mainly rely on heat release characteristics parameters, rather than sample apparent change. As a comparison, the fire performance of common 30mm PU board is also carried out, results are listed in table 1.

Table 1 Heat release characteristic

sample	HRR peak, kW	FIGRA _{0.2MJ} , W/s	THR _{600s} , MJ
insulation photovoltaic building component	12.0	20.3	0.2
30mm PU board	18.9	398.5	2.5

As can be seen, the FIGRA index of 30mm PU board is more than 20 times than that of insulation photovoltaic building component, while the total heat release is more than 10 times than insulation photovoltaic building component.

This is because 30mm PU board is faced to flame directly without any protection in the test process, burning rapidly and violently and heat release quickly. But 10mm thickness PU board enclosed in insulation photovoltaic building component is covered by several protection layer, so there is no flammable burning on PU insulation board, heat release is relatively slow, the total heat release is relatively low.

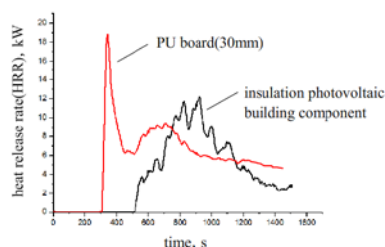


Fig 3 Heat release rate

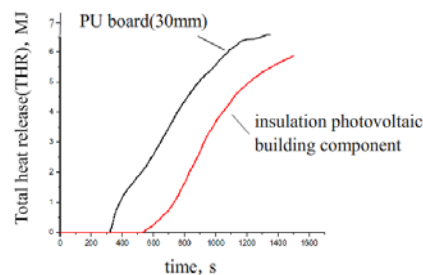


Fig 4 Total heat release

It can be seen from heat release rate (Fig 3) and total heat release (Fig 4), PU board test heat release begins earlier than that of insulation photovoltaic building component nearly 200s, this is because of the protective layer covered on the PU insulation board. When burning begins, PU board burning quickly and has a higher heat release peak than that of insulation photovoltaic building component. This is also because of protective effect of external nonorganic material. In addition, the total heat release of PU board accumulates quickly in the initial stage of combustion, the curve slope is larger, and at the end of the test with the gradual depletion of combustible materials, the curve slope decreases gradually. And the heat release curve of insulation photovoltaic building component products is relatively smooth, which means the heat accumulation rate is relatively low.

3、fire test method of insulation photovoltaic building components installed on the roof

The insulation photovoltaic building components installed on the roof have different characteristic from that of the product installed on the building external wall because of the

horizontal working state, and for some special roof, the insulation photovoltaic building components may be installed inclined to a certain angle. So the corresponding test method must be designed for this kind of produce according to the working state.

EN1187 is the most common test method for Test method for insulation photovoltaic building components installed on the roof around the world, and such methods also can be suitable for other kinds of roof building materials. In China the GB method is now being worked out, mainly according to EN1187. The main characteristics of this methods are listed in Table 2.

Table 2 Main test characteristic of EN1187

Ignition source	Charcoal fire A	Shavings (width: 2mm; Thickness: 0.2 mm~0.3mm; total mass: 600g)
	Charcoal fire B	Two blocks(density:56050kg/m ³ ;dimension:40mm×40mm×40mm)
	Charcoal fire C	Two wood cribs (density:560±50kg/m ³ ;dimension:150mm×150mm×57mm)
substrate	Wood particleboard is adopted as substrate when applied to combustible surface; Metal profiles is adopted as substrate when applied to metal surface.	
test method	<p>Method A: ignite the load Shavings after placed at a proper position of the sample inclined to a certain angle.</p> <p>Method B:place the ignited block at a proper position of the sample after wind velocity calibration.</p> <p>Method C: place the ignited wood crib at a proper position of the sample after wind velocity and surface heat radiation calibration.</p>	

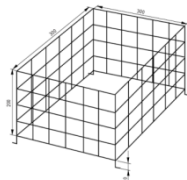


Fig 5 : Method A : Shaving container

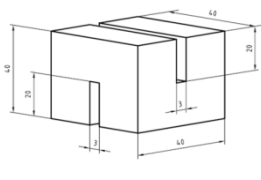


Fig 6: Method B: wood block

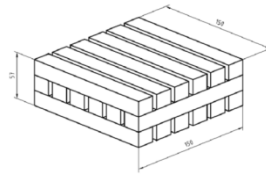


Fig 7 : Method C:wood crib

The fire performance of insulation photovoltaic building components inclined to different angle can be tested using method A, and ignition source selection is representative. Wind velocity calibration is designed in method B considering the influence by environmental wind speed. When the adjacent buildings are burning, heat radiation may be formed on the roofing materials, this will inevitably affect the combustion process and heat release characteristics of samples, so heat radiation calibration is also added in method C.

4 conclusion

Building insulation photovoltaic components have a wide range of uses and future market prospects. Because of its structure and working mode characteristics, the burning performance of building insulation photovoltaic components is different from common organic insulation board. In this paper common test methods according to different operation mode are introduced, and the burning performance is compared between building insulation photovoltaic components and common PU board. The conclusion will greatly benefit the research、development and fire protection of the products.

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