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# Fire safety evaluation of different internal insulation measures in European and Danish contexts

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## Abstract

There has been an increased focus on energy upgrading the existing building stock, including the use of internal insulation. The focus in previous studies examining internal insulation has mainly been energy savings and later durability in relation to moisture safety. None of the studies have reported whether or not the applied retrofit measures fulfil the fire regulations. The height of the building is also considered in fire regulations, and therefore, measures that are applicable in e.g. single-family houses might not be applicable in apartment buildings. This study includes a review of 45 internal insulation scenarios in 38 case buildings. These measures are evaluated against the EU-harmonized and Danish fire regulations. The study evaluates, whether the measure is applicable at all floor levels or not.

## Introduction

According to EN 13501:2018 *Fire-safety classification of construction products and building elements (part 1 or 2)*, a material to be used for internal insulation on walls is at least material B-s1,d0 and if not, must be covered with a material, thus the system as a whole obtain class K<sub>1,10</sub> B-s1,d0 or K<sub>1,10</sub> D-s2,d2 depending on the room, application category and building height. The requirements do, to a certain degree, depend on the building height, as high-rise buildings require more

time for evacuation. In Denmark, insulation with a fire class less than D-s2,d2 may be used in buildings with a top floor level up to 9.6 m above terrain if covered by K<sub>1,10</sub> B-s1,d0 cladding or a EI 30 building component and up to 22 m if covered by a EI 30 A2-s1,d0 building component. Insulation that is at least material class D-s2,d2 may be used in buildings up to 22 m if covered by K<sub>1,10</sub> D-s2,d2 cladding.

## Method

Information collected for case buildings included: number of floors, state of the building, types of exterior surfaces, types of installed insulation systems, and the hygrothermal performance. The hygrothermal performance of insulation systems was evaluated and only systems showing non-critical relative humidity levels were selected. Fire classifications for insulation and cladding materials were obtained from performance documents. Evaluation was done according EU-harmonized and Danish fire regulations by assessing the type of insulation material and the type and thickness of the internal cladding, to determine if the insulation material was sufficiently protected to be installed in the building in question.

## Results

The results of the data collection and evaluation of applied insulation systems are summarized in **Table 1**. The evaluation showed that 30 out of 45 insulation scenarios met the fire regulations.

## Discussion and conclusions

The evaluation showed that not all the reviewed projects met the EU-harmonized fire regulations. Insulation was typically protected with a cementitious plaster or fire gypsum boards. For many project, especially in countries outside EU, the requirements are not met for the analysed projects in this study, which might be implied in different non-EU regulations. In addition, for some project it was not possible to judge the solutions due to lack of design information. The adaption of national fire regulations is exemplified for Denmark (two rightmost columns in Table 1). In the Danish projects, the plastic foam insulation products met the fire regulations for low-rise buildings with top floor level less than 9.6 m above terrain (3-storey building,). However, these systems would not be suitable for high-rise buildings up to 22 m above terrain (6-storey building). It was found that all four cases with phenolic foam and one case with polyurethane foam with capillary

channels did not meet the fire regulations, in relation to buildings taller than 3 stories, as a result the occupants would have less time than intended to evacuate. Fire protection of these systems comprised a standard gypsum board or a thin cementitious plaster layer (B-s1,d0). In high-rise buildings, such insulation products require protection by an EI 30 A2-s1,d0 building element (90 mm masonry or 75 mm lightweight concrete or lightweight clinker). It must be mentioned that the height-dependent fire requirement have a historical reason, and largely depends on the equipment of the fire rescue services. Other EU countries will most likely have similar heights requirements. To summarize: some insulation systems may be applicable in low-rise buildings but require more extensive protection measures in high-rise buildings. Less flammable materials such as CaSi, AAC and mineral wools give more flexibility for installation as internal insulation and less risk. The authors recommend that there come more focus on documentation of chosen internal insulation systems in relation to the building in question.

**Table 1.** Projects and fire classifications for insulation and cladding materials. Projects are grouped according to material type. The last two columns concerning building height and suitability are based on national fire regulations for Denmark.

Insulation		Internal cladding			Building height	
Material	Fire classification	Material	Thickness [mm]	Fire classification	Buildings up to 9.6 m <sup>1</sup>	Buildings between 9.6 m and 22 m <sup>2</sup>
Calcium silicate (CaSi)	A1	Plaster	2-10	A1 / B-s1,d0	Yes	Yes
Polyurethane	D-s2,d0	Gypsum board	Not given	Not given	Yes	No
Polyisocyanurate	F	Gypsum board	25	Not given	Yes	No
Extruded polystyrene	E	Gypsum board	12.5	A2-s1,d0	Yes	No
Phenolic foam	C-s1,d0	Gypsum board +/- plaster	12.5 (+ 3)	A2-s1,d0	Yes	No
Polyurethane foam with capillary channels	E	CMT plaster	10-20	A1	Yes	No
Autoclaved aerated concrete (AAC)	A1	CMT plaster	5-10	A2-s1,d0	Yes	Yes
Glass wool in studwork with active dehumidification	A2-s1,d0	Fiber gypsum board + gypsum board	2 x 12.5	A2-s1,d0	Yes	Yes
Aerogel	C,s1,d0	Gypsum board	25	Not given	Yes	No
Mineral wool/aerogel	B-s1,d0	Gypsum board	10	Not given	Yes	Yes
Wood fiber board	E	Lime plaster	8	A2-s1,d0 / B-s1,d0	Yes	No
Vacuum insulation panel	F	Gypsum board	25	Not given	Yes	No

CMT: Cementitious; +/-: system applied with/without 3 mm interior finishing plaster. <sup>1</sup>Suitable for buildings with a top floor level lower than 9.6 m above terrain. <sup>2</sup>Suitable for buildings with a top floor level between 9.6 m and 22 m above terrain.