ALUMINIUM AND FIRE SAFETY

1 / INTRODUCTION

Aluminium is the most commonly used non-ferrous metal.

The excellent properties of aluminium alloys – their lightness, high strength-to-weight ratio, corrosion resistance, thermal properties, ease of fabrication and excellent recyclability – lead to their widespread use and result in substantial economic and functional benefits to society.

Aluminium and its alloys in solid form do not burn and do not contribute to the spread of fire.

It is widely known that aluminium powder can be made to burn, if ignited under very specific conditions (similarly to other metal powders, such as steel, zinc, lead, copper or titanium), but under the usual solid and continuous form, aluminium does not burn.

Under normal circumstances, aluminium does not burn.

Aluminium melts at between 660 to 680°C. The melting point of a metal, like its density, strength, or corrosion resistance, is a characteristic that can be measured and used to design the most effective component for any application.

Worldwide every year, more than 100 million tonnes of ingots and scrap (in the form of plate, sheet, foil, extrusions, forgings, castings, wire and various production scrap) are directly exposed to flames in re-melting furnaces at temperatures much higher than in a normal fire. The metal within does not burn, but rather melts down, to be recovered and recycled into new aluminium products.

In product manufacturing, electric arc, plasma or laser welding are widely used to join aluminium parts that are locally exposed to temperatures far exceeding aluminium's melting point without them catching fire.

Aluminium cookware can be used on gas stoves - and aluminium foils in barbecues - safely and without risk of fire.

These examples illustrate that aluminium is non-combustible and does not contribute to the spread of fire.

2 / ALUMINIUM IN BUILDING APPLICATIONS

Aluminium is used extensively in buildings. Lightweight but durable, aluminium alloys are the material of choice for curtain walling and other framed products such as doors and windows. The metal is widely used for exterior cladding and roofing, suspended ceilings, wall panels and partitions, heating and ventilation equipment, solar shading devices and light reflectors.

European regulations classify aluminium and its alloys (when not in a powdered form) as Class A1 'No contribution to fire' - the highest "reaction to fire" rating for construction products.

To meet specific customer needs, aluminium building products are often surface treated, through 'anodic oxidation' (anodised) and 'organic coatings' (painted) processes. Bare and anodised aluminium products and a wide range of painted aluminium products are non-combustible, i.e. Class A1 or Class A2.

Another product type, the aluminium composite panel (ACP), also named aluminium composite material, is a millimetres-thick combination of two aluminium cover sheets and a polymer, mineral or mixed material core. Offering precise flatness and excellent formability, ACPs have a wide range of applications, including cladding and roofing. ACP core materials can include fire-retardant and non-combustible options.
This core material determines the fire behaviour of the panel.

Aluminium profiles, sheets and composite materials are often used in combination with other materials as part of other construction products or solutions, the most common ones being doors, windows or complete facades in the form of curtain walls or cladding.

MORE INFORMATION HERE

ALUMINIUM AND FIRE SAFETY

3 / ALUMINIUM IN STRUCTURAL APPLICATIONS

Structural aluminium alloys have useful maximum working temperature limits that range between 200 and 250° C.

When aluminium is used for structural applications, i.e. related to the mechanical resistance and stability of a structure, like a bridge, a boat, a warehouse, or an off-shore construction, assessing the reaction to fire is not enough, it must be complemented with an assessment of how far product performance will be affected when exposed to fire.

Depending on the specific alloy and its temper (the heat treating process used to improve its properties) as well as on the use of fire resistant insulating layers (including intumescent coatings that swell up when heated), the heat generated by a fire can affect the structural capacity or function of an aluminium structural application.

The thermal conductivity of aluminium is about four times that of steel, and its specific heat about twice that of steel. This means that heat is conducted away faster and a greater heat input is necessary to bring the same mass of aluminium to a given temperature compared with steel.

Where an aluminium structure is exposed to the heat of a fire, the relatively high thermal conductivity enables the heat to be rapidly conducted away from the exposed area. This helps to reduce hot spots, where significant localised property loss could occur, thus extending the serviceability period.

It will, however, cause the temperature to rise elsewhere. The extent of dissipation of heat elsewhere in the structure will depend on the degree of thermal insulation provided to the aluminium elsewhere in the structure.

The high reflectivity of weathered aluminium makes it an excellent heat shield material to protect personnel on stairs and walkways during a fire, and to prevent the temperature of the aluminium structure itself exceeding the working limits during the design time period.

Some of the above-mentioned characteristics are also addressed in European standards such as the part 1.2 of EN 1999 (better known as Eurocode 9). This standard provides a common approach for the design of aluminium structures in the accidental situation of fire exposure. Furthermore, it plays a fundamental role in identifying requirements that are necessary to fulfil the load-bearing function of aluminium structures exposed to fire, as to avoid their premature collapse.

Examples of fire-safe designs of aluminium helicopter decks are provided through the link below.

MORE INFORMATION HERE

4 / ALUMINIUM IN TRANSPORT VEHICLES

Aluminium is used for a host of applications in transport vehicles: bicycles, cars, trucks, trailers, buses, coaches, trains, boats and aircrafts. Its lightweight characteristics help to increase vehicle efficiency, reducing fuel consumption and consequently decreasing tailpipe CO_2 emissions from vehicles with internal combustion engines, or/and electricity related emissions for electric and plug-in hybrid vehicles.

Aluminium is widely used in tanks for inland transport of flammable products, like fuels, and is among the few materials allowed for this purpose. This is due to, among other factors, the safety provided by the aluminium non-sparking property in all environments and with all materials, with only one known exception: sparking when aluminium enters in collision with rusty iron [see the chapter about 'Sparking'on page 5]. This reaction is easily avoided using protective coatings, such as paintings.

Furthermore, aluminium can be used as filler inside fuel tanks to dissipate heat during undesired combustion (anti-explosive function).

Aluminium is also used as heat shield in various places of transport vehicles, e.g. between the exhaust pipe and the floor of a car.

5 / OTHERS

Under exceptional circumstances, particular reactions can take place.

MORE INFORMATION HERE

ANNEX

2 / ALUMINIUM IN BUILDING APPLICATIONS

Windows and doors

In general building applications, no special requirements are placed on fenestration products regarding fire ratings.

However, with multi-storey residential and commercial buildings, fire rated products are required at strategic locations to prevent or hinder the spread of fire.

How to assess the fire performance of aluminium windows and doors?

Aluminium windows and doors are assessed against several fire-related characteristics, including the reaction of components to fire, smoke control, ability to release and self-closing in case of fire.

For example, in the European Union, the standard EN 16034, legally bound to the Construction Products Regulation (CPR), specifies test/assessments/ calculation methods and compliance criteria for fire resistance and/or smoke control products intended to be used in fire and/or smoke compartmentation and/or escape routes.

Curtain walls

A curtain wall is a window-derived product (closes an opening), but one which provides all the required functions of a wall. It generally consists in a kit made up of:

- a framework of horizontal and vertical aluminium profiles, connected together and anchored to the structure of a building;
- fixed and/or openable infills that are transparent or not (such as windows, glass panes or opaque panels), hung from the support profiles.

Installation of a curtain wall

How to assess the fire performance of a curtain wall?

In curtain walls, aluminium components are usually combined with steel, glass, plastic and rubber materials. The components of the kit are pre-defined by the manufacturers or their system suppliers. Each have detailed technical specifications including their safety rating in case of fire.

For example, in the European Union, the standard hEN 13830, legally bound to the Construction Products Regulation (CPR), specifies requirements, provides test/assessments/calculation methods and compliance criteria regarding reaction to fire, fire resistance or fire propagation of curtain walling kits.

ANNEX

2 / ALUMINIUM IN BUILDING APPLICATIONS

Cladding

Cladding is the protective material attached to the exterior-facing side of a blind wall. Unlike curtain walls, claddings do not provide all the required functions of a wall, as they are applied over walls. By extension of the above definition, the term cladding is often used to name a wider system, which includes thermal insulation, externally applied to a wall, while the cladding 'as such' is the exterior skin. Furthermore, when an air gap is present between the exterior skin and the underlying wall (thermally insulated or not), the whole system is often named 'ventilated cladding'.

Untreated, coated or anodised aluminium sheets can be used for the exterior skin, as can aluminium composite panels (ACPs) and honeycomb panels.

How to assess the fire performance of a cladding solution?

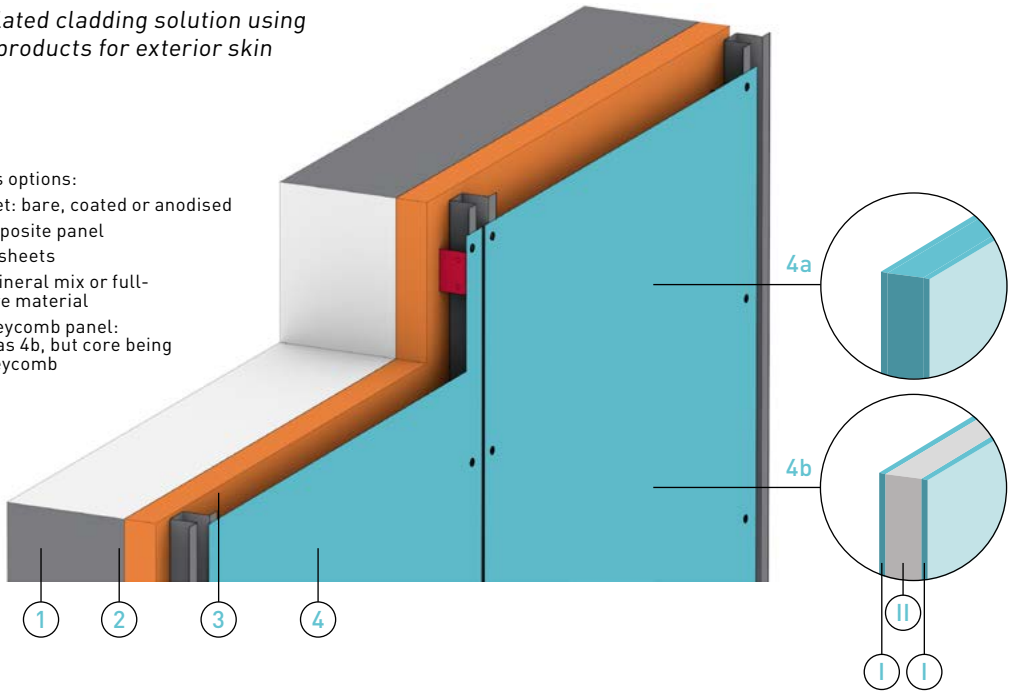
Unlike curtain walling kits, the components of a cladding solution are, in most cases, NOT all pre-defined by the manufacturers or their suppliers.

In Europe, despite the existence of harmonised technical specifications (e.g. European Assessment Document 090062-00-0404 in the European Union), the safety in case of fire of the final solution applied to the building is assessed according to national test methods.

Exterior skin material (4), thermal insulation material (2), and fire barriers all have an influence on the fire performance of a cladding solution.

Example of a ventilated cladding solution using aluminium-based products for exterior skin

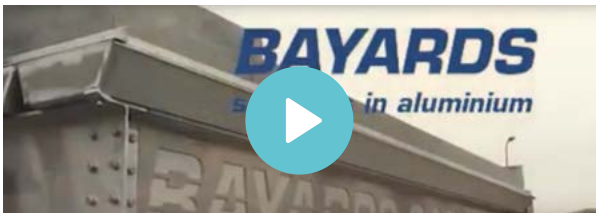
1. Wall
2. Thermal insulation
3. Air gap
4. Exterior skin, various options:
   - 4a. Aluminium sheet: bare, coated or anodised
   - 4b. Aluminium composite panel
     - I. Aluminium sheets
     - II. Polymer-mineral mix or full-mineral core material
   - 4c. Aluminium honeycomb panel: same principle as 4b, but core being aluminium honeycomb



ANNEX

3 / ALUMINIUM IN STRUCTURAL APPLICATIONS

Fire testing of aluminium helicopter decks



5 / OTHERS

The "Thermite Reaction"

Aluminium ions have a great affinity for oxygen ions (this is why aluminium is so durable as it is almost always coated by a thin "passivation" layer of protective aluminium oxide that naturally forms on its surface). In powdered form and under specific conditions, pure aluminium can react with other powdered metal oxides (such as iron (III) oxide), stripping them of their oxygen ions in what is known as the Thermite Reaction.

Fe_2O_3 + 2 Al -> 2 Fe + Al_2O_3 + Heat

The exothermic reaction of the metal with oxygen produces significant quantities of energy in the form of heat (and light).

(The utilization of steel tools to handle molten aluminium is quite common and it is therefore very important the use of protective material to avoid rust (iron oxide).)

Sparking

The thermite reaction can also happen under very exceptional circumstances with aluminium in solid form. This can happen if an aluminium object enters in collision with a slightly rusty steel or iron object at an angle between 35 and 55°.

This may generate a spark, so care needs to be taken in these specific environments where combustible gases could be ignited (for instance in coal mines).

Steam explosions when handling molten metal

Explosions due to steam in molten metals have nothing to do with fire.

Any moisture that might be trapped on the surface of the solid metal that is placed into a furnace for melting should be removed (usually by preheating in a lower temperature oven). This is because any trapped moisture, exposed to the high temperature in a furnace, will immediately form steam, expanding to over 1500 times its volume in less than a second, causing a "steam explosion" and potential ejection of molten metal. This risk is not specific to molten aluminium; it needs to be managed for all metals (and other processes where there is the potential for trapped water to superheat).

ANNEX

REFERENCES

- European Commission Decision 96/603/EC establishing the list of products belonging to Class A 'No contribution to fire' based on the 'reaction to fire' classification system for construction products defined in Commission Decision 94/611/EC, later amended by European Commission Decision 2000/605/EC to follow the new classification system defined in Commission Decision 2000/147/EC, where Class A1 substituted the former Class A.
- Standard EN 16034 Pedestrian doorsets, industrial, commercial, garage doors and openable windows. Product standard, performance characteristics. Fire resisting and/or smoke control characteristics
- Standard hEN 13830 Curtain walling. Product standard
- Agreement for the transport of Dangerous goods by Road: https://www.unece.org/fileadmin/DAM/trans/danger/publi/adr/adr2017/ADR2017E_web.pdf
- Aluminium and fire in fiery mines and gas hazardous circumstances, extract from Aluminium Federation of Southern Africa (AFSA)'s "Introduction to aluminium" Dr. A. E. Paterson, June 2004
- Aluminium and Fire, UK Aluminium Industry Fact Sheet 11, Aluminium Federation AlFed

DISCLAIMER

ABOUT EUROPEAN ALUMINIUM

European Aluminium, founded in 1981 and based in Brussels, is the voice of the aluminium industry in Europe. We actively engage with decision makers and the wider stakeholder community to promote the outstanding properties of aluminium, secure growth and optimise the contribution our metal can make to meeting Europe's sustainability challenges. Through environmental and technical expertise, economic and statistical analysis, scientific research, education and sharing of best practices, public affairs and communication activities, European Aluminium promotes the use of aluminium as a material with permanent properties that is part of the solution to achieving sustainable goals, while maintaining and improving the image of the industry, of the material and of its applications among their stakeholders. Our 80+ members include primary aluminium producers; downstream manufacturers of extruded, rolled and cast aluminium; producers of recycled aluminium and national aluminium associations are representing more than 600 plants in 30 European countries. Aluminium products are used in a wide range of markets, including automotive, transport, high-tech engineering, building, construction and packaging.

Follow us on Twitter @EU_Aluminium

Contact details
European Aluminium
Avenue de Tervueren 168
1150 Brussels, Belgium
Phone +32 2 775 63 63
communications@european-aluminium.eu
www.european-aluminium.eu

EUROPEAN ALUMINIUM