

ALUMINIUM and FIRE

Introduction

Combustion is a high temperature exothermic reaction between a fuel and normally oxygen, that reacts or oxidises the fuel to an oxide, often a gaseous product. Sufficient heat has to be applied to the fuel to convert it into a gaseous form and to ignite the oxidation reaction. Chemically, solid fuels have to undergo “Endothermic” pyrolysis to convert them into gaseous fuels whose combustion then supplies the heat for continued “Exothermic” combustion. An “Exothermic” combustion reaction is one that evolves heat, making combustion self-sustainable.

Aluminium

Aluminium metal and all its alloys, in both solid and molten states, including all products forms, wire, extrusion, sheet and foil, are “non-combustible”, meaning they do not burn or combust when exposed to fire. Solid Aluminium is a non-combustible material and therefore inflammable, so cannot catch fire.

Aluminium in Construction

In Europe a series of fire disasters highlighted the importance of safety in the event of fire. The European Commission, supported by a Group of National Fire Regulators, proposed a completely new classification system, based partially on existing test methods, but partially, and critically for many construction products, on a completely new test, the so-called “single burning item” (SBI) test.

The European classification standard adopted in the United Kingdom as BS EN 13501-1 “Fire classification of construction products and building elements”, ranks construction materials in 7 classes with regard to their reaction-to-fire fire behaviour: A1, A2, B, C, D, E and F

BS EN 13501-1:2007 Aluminium and Aluminium alloys, (not in finely divided form) are included in those Materials to be considered as reaction to fire Classes A1 and A1FL (non-combustible) as provided for in Decision 2000/147/EC.

Aluminium offers “No contribution to fire” as provided for in Decision 94/611/EC implementing Article 20 of Council Directive 89/106/EEC on construction products.

BRITISH STANDARD	
Fire classification of construction products and building elements —	BS EN 13501-1:2007
	Part 1: Classification using data from reaction to fire tests

Fire and Aluminium Building Materials

Aluminium alloys are ‘non-combustible’ as defined by BS 476: Part 4 and the 1974 SOLAS Convention (as amended).

Aluminium alloys are classified as Class 1 - providing the greatest resistance to surface spread of flame, under BS 476: Part 7: 1987 Method for the classification of the surface spread of flame of products,


Non-combustible materials are “any material which when tested to BS 476: Part 11 1982 (1988) does not flame or cause any rise in temperature”

BS 476: Part 3 covers external fire exposure roof tests and the classifications laid down in the standard range from AA to DD. The first letter refers to the fire penetration performance and the second letter to the surface spread of flame.

Aluminium and its alloys are rated AA, the highest possible classification. Materials are also tested for fire propagation performance to BS 476: Part 6 (1989) and coating systems are taken into account. Aluminium achieves excellent ratings under this Standard.

Building Regulations

Building regulations in England, "Fire safety: Approved Document B", additionally consider the propagation of fire, so consider both the spread of flames and the amount of heat added to a fire by the energy output of burning materials. Aluminium is Classed as A1 Non-combustible and does not flame or cause any rise in temperature."

Comparison of Technical Guidance Document B categories and relevant EN test requirements		
National classification	Euroclass category	Safety level
Non-combustible	A1	
Material of limited combustibility	A2	
Class 0	B	
Class 1	C	
Class 3	D	
N/A	E	
N/A	F	

Aluminium and Fire

Aluminium can be infinitely recycled without loss of properties, using only 5% of the water, oxygen and energy required to extract the ore and primary smelt! Each year hundreds of thousands of tons of aluminium scrap are fed into remelt furnaces and heated up to and beyond the melting point without burning!

Aluminium in the form of finely divided powder or flake oxidises exothermically, but this is a very special case because of the very large surface-area-to-weight ratio. Dust or powders 420 microns (40 mesh) or finer, including Aluminium, are potentially explosive! Aluminium then behaves in a similar way to other finely divided materials such as iron and titanium, tea, flour and coal, all of which will also readily oxidise exothermically in the powder form.



During and following the Falklands conflict between Great Britain and Argentina, several misleading statements appeared in the press, suggesting that aluminium alloys, used in the superstructure of some of the ships that were sunk, had burned and contributed to the loss of these ships. The Defence White Paper published on 14 December 1982 concluded, 'there is no evidence that aluminium has contributed to the loss of any vessel'. Similar conclusions were reached by the Ministry of Defence Working Party convened to review ship design. Aluminium, like any other material, has advantages and disadvantages in any given set of circumstances. Where the balance is in favour, aluminium should be used in warships or elsewhere.'

Aluminium alloys have melting points between 550°C and 660°C so if exposed to a prolonged fire environment, provided that the metal's temperature passes the melting point, they will melt, without releasing harmful gases, but not burn.

- Latent heat of melting will lower fire temperature.
- Molten Aluminium will flow as liquid.
- Liquid Aluminium will solidify rapidly away from heat source.

In fire tests on aluminium materials, when the temperature exceeds the melting point, in the range 600-660°C, the aluminium surface exposed to the fire can be seen to melt, but it does not burn. At the end of the fire test, the metal remains as a solidified pool.

The thermal conductivity of aluminium is around four times that of steel and its specific heat 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, so 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, necessary to provide fire protection in that area.



The high reflectivity of weathered aluminium is 80% to 90%, compared with 5% for painted steel and 25% for stainless steel. This is of considerable benefit and will assist in prolonging endurance of an aluminium structure in a fire. The photograph is a good example of the behaviour of aluminium in the massive form in a fire. A car, with aluminium alloy wheels, was caught in a forest fire that swept over the car and moved on. Afterwards it was found that the aluminium wheels had melted, molten aluminium had run off and collected in a

pool of metal which solidified as the fire moved on and the temperature fell. The aluminium had not burnt.

Fire Protection

Three principal methods of fire protection are employed, using fire resistant insulating layers protecting an underlying aluminium component. Examples have used ceramic fibre, intumescent coatings applied to the aluminium element or composite systems with aluminium external skins. The latter have been demonstrated to be applicable both as load-bearing elements and as add-on panel systems. The aluminium skin on the exposed fire side of the system is sacrificial and melts, revealing a supported fire insulation material which provides the required period of fire performance and protects the remaining aluminium elements of the system. A small increase in insulation thickness is usually required to take account of the lower maximum working temperature limit of aluminium compared to steel.

The use of radiation shielding around structures such as stair towers and walkways can provide protection, not only to personnel during a fire but prevent the temperature of the aluminium structure exceeding the working limits during the design time period.

As with all metallic materials, as the temperature increases the strength of aluminium alloys is reduced at a rate dependent on the alloy, The structural aluminium alloys have useful maximum working temperature limits that range from 200° to 250°C. Above this temperature the strength is significantly reduced.

Further information about aluminium and aluminium alloys, their production, fabrication, and end use can be obtained from:

- Aluminium Federation www.alfed.org.uk
- Council for Aluminium in Buildings www.c-a-b.org.uk
- European Aluminium Association in Brussels www.european-aluminium.eu
- International Aluminium Institute in London www.world-aluminium.org