The Building Envelope Authority

Guidance Documents

APRIL 2019

GD 26A ALUMINIUM FABRICATIONS AND FLASHINGS: INTERIM GUIDANCE

INTRODUCTION

At first consideration the design and installation of aluminium fabrications is a simple matter.

Experience though has shown that in service, aluminium fabrications are a complicated interaction between multiple factors, and the result can be a weak and short-lived solution.

The MCRMA recognises that a guidance document describing the best practice in the design of aluminium fabrications for metal clad buildings is needed by the industry.

The primary issues are thermal expansion and contraction and the accommodation of associated stresses and movements by the fabrication, fasteners, seals and supporting structure, for example:

- Light gauge steel angles or rails
- Cladding system (light gauge steel or aluminium)
- Hot rolled steel angles or rail
- Timber
- Masonry

There are different approaches to achieving this, and some widely used methods contradict each other, ie floating fixed or dead fixed.

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To gain a more complete understanding of the actual stresses and movement undergone by typical aluminium fabrications and the effects of different designs and installation strategies, the MCRMA has commissioned a programme of research and testing.

An aim of the research programme is to establish the differences between theoretical implications and industry experience; to gain a more complete understanding of the behaviour of aluminium fabrications under temperature changes, and to refresh the optimum design criteria and rules in relation to materials, fabrication shapes and dimensions, fasteners, supporting structure and seals.

The research is on-going.

As an interim measure this document has been published pending the outcome of the research. It includes Appendix A, a summary of available temperature range advice from Standards, initial research output and other sources plus a short explanation of the theoretical physics of thermal expansion/contraction and thermal stresses.

Design advice

Designers preparing specifications and construction details for aluminium fabrications (>= 1.0mm thick) should consult with the appropriate MCRMA member companies for detailed and project specific design advice.

MCRMA members will provide advice on best practice for the design intent, including but not restricted to, fabrication size, shape, thickness and grade of materials. Additionally, members will offer recommendations on support structure, fixing method, fixing type and sealants.

These companies include:

- Aluminium fabrication manufacturers
- Fastener manufacturers
- Sealant manufacturers

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In addition, some members also have the capability to model the more complicated fabrications by finite element analysis (FEA) to establish an appropriate design.

Guidance Document GD 26

The MCRMA intends to re-publish guidance document GD 26 on the design and installation of aluminium fabrications once the research is complete. This will be published via the MCRMA website.

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APPENDIX A: TEMPERATURES, EXPANSION AND FORCES

1.0 THERMAL MOVEMENT

Temperature ranges

There are a number of sources of guidance for maximum and minimum temperatures that a building component will undergo. These are described below and the maximum and minimum values are shown in table 1.

1.1 BS EN 1991-1-5:2003: Eurocode 1: Actions on structures - Part 1-5: General actions - Thermal actions

The Standard deals primarily with structures and bridges but is also applicable to cladding [1.1(1)]. The National Annex to BS EN1991-1-5 includes two graphs giving minimum (T_{min}) and maximum (T_{max}) temperature isotherms for the UK [figs NA1 and NA2). These are then modified by a factor for orientation (i.e. south west facing: light colours, T_4 = +30ºC, and dark colours, T_5 = +42ºC).

The summary table 1 below shows the worst-case values for the UK as a whole.

BS EN1991-1-5 does not differentiate between insulated and uninsulated assemblies.

National Annex to BS EN 1991-1-5:2003 (NA.2.21) advises an initial (installation) temperature T_o of 0ºC for expansion and 20°C for contraction.

1.2 BS5427:2016 + A1:2017 Code of practice for the use of profiled sheet for roof and wall cladding on buildings

BS 5427 gives a maximum temperature change over 24 hours, compared with maximum and minimum temperatures provided by other sources. BS 5427 table 7 gives a maximum 24-hour temperature change of 50°C for light colours and 70°C for dark colours.

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1.3 Historic industry data

Historic industry data recorded maximum temperatures of various materials and colours through the extreme summer heat wave (drought year) of 1976. The spell of hot weather, from mid-June to the end of August, included 15 consecutive days where a maximum temperature of 32°C or more was recorded somewhere in the UK.

The measurements were taken on insulated assemblies and assemblies with a nominal 25mm air gap beneath. No minimum values are available.

1.4 University of Bath

In a 2014 research paper, *Factors Affecting the Accommodation of Thermal Movement in Halter Based Aluminium Standing Seam Systems* carried out by David Cottrell at the Department of Architecture and Civil Engineering of the University of Bath, temperatures and potential movement were analysed. While this is for aluminium roof systems with very long roof sheets, the principles and temperature values are relevant to fabrications. Data is provided for maximum and minimum temperatures for insulated aluminium systems only. Guidance is offered for installation temperatures.

The minimum surface temperature of -28°C is a minimum temperature of -20°C together with a -8°C allowance for drop in temperature due to night sky radiation. Initial (installation) temperature T_o of -5°C for expansion and 25°C for contraction.

1.5 Finite element analysis

Commissioned by the MCRMA, Oxford Brookes University has modelled aluminium fabrications using finite element analysis (FEA), including insulated and uninsulated assemblies (nominal 25mm air gap), including various surface reflectivity/colours. The minimum surface temperatures include the night time clear sky radiation effects.

Summary results are included in table 1.

Summary of temperature ranges

Source	Light colours		Dark colours		Insulated or air gap?
	Max °C	Min °C	Max °C	Min °C	
BSEN1991-1-5	65	-21	77	-21	n/a
BS 5427 (24hr temp range)	50	n/a	70	n/a	n/a
Historic (steel)	61	n/a	71	n/a	Insulated
Historic (steel)	49	n/a	44	n/a	Nom 25mm air gap
Historic (mill AL)	67	n/a	n/a	n/a	Insulated
Historic (mill AL)	44	n/a	n/a	n/a	Nom 25mm air gap
University of Bath	62	-28	78	-28	Insulated
FEA	68	-13.7	88	-14.3	Insulated
FEA	43	-8	65	-8.7	Nom 25mm air gap

Table 1 Summary of minimum and maximum temperatures

Industry and FEA data indicate that uninsulated assemblies can have lower maximum temperatures with the figures above ranging from 20% to 38% lower; average 31% lower.

Maximum temperatures also vary around the country and an engineer should refer to National Annex to BS EN 1991-1-5:2003 for temperatures specific to their project.

Selecting a maximum temperature for an application is not a precise science. Colour, orientation, location and cleanliness all have an effect. If in doubt, select data for dark colours.

For the examples in this appendix, the following values in table 2 are used, based primarily upon National Annex to BS EN 1991-1-5:2003. For illustration, maximum temperatures for uninsulated assemblies are shown 30% lower than the insulated values.

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Surface colour	T_{max} ∘C (Insulated)	T_{max} ∘C (air gap)	T_{min} ∘C
Light coloured (Grey/white)	65	70% of 65 = 46	-21
Dark coloured (Slate grey/ mill finish aluminium)	77	70% of 77 = 54	-21

Table 2 Minimum and maximum temperatures used in the examples given in this document

Initial (installation) temperatures T_o of 0°C for expansion and 20°C for contraction are used in examples.

2.0 POTENTIAL EXPANSION AND CONTRACTION

The calculation of expansion and contraction per metre of section includes the coefficient of expansion, minimum or maximum temperatures and temperatures at installation.

Movement = $\alpha.\Delta T$

α = the coefficient of expansion for aluminium = 23.3 x 10-6 /°C

ΔT = temperature change = T_{max}-(- $T_{o\ (exp)}$) or T_{min}-(- $T_{o\ (con)}$), °C

T_{max} = Max surface temperature, °C

T_{min} = Min surface temperature, 0°C

$T_{o\ (exp)}$ = 0°C

$T_{o\ (con)}$ = 20°C

Surface colour	Insulated or air gap		T_{max}	$T_{o\ (exp)}$	Expansion	BS 5427 sect 7		T_{min}	$T_{o\ (con)}$	Contraction	Overall movement
			∘C	∘C	mm/m	mm/m		∘C	∘C	mm/m	+/- mm/m
Light coloured (Grey/white)	Insulated		65	0	1.51	1.0		-28	20	-0.96	1.51
Dark coloured (Slate grey/ mill finish AL)	Insulated		77	0	1.79	1.3 or 1.5		-28	20	-0.96	1.79
Light coloured (Grey/white)	Air gap		46	0	1.07	1.0		-28	20	-0.96	1.07
Dark coloured (Slate grey/ mill finish AL)	Air gap		54	0	1.26	1.3 or 1.5		-28	20	-0.96	1.26

Table 3 Summary of expansion and contraction

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Fasteners must be placed centrally to an oversize hole or slot (using a self-centring tool if possible). The BS 5427 movement is from section 7.1.2.1, table 7 and section 7.1.2.6 of the Standard.

3.0 POTENTIAL FORCES

The example below is for dark coloured uninsulated aluminium fabrications (i.e. with an air gap beneath the fabrication).

The restrained stress exerted by thermal effects is related to the cross-sectional area and temperature change. Stress = $\alpha.E.\Delta T$; force = $\alpha.E.\Delta T.A$

α = the coefficient of expansion for aluminium = 23.3×10^{-6} /°C

E = Young's modulus = 70000N/mm^2

ΔT = temperature change = 54-(-0) = 54°C (Dark colour, uninsulated)

A = cross-sectional area of a section or fabrication = girth x thickness, mm^2

$\alpha.E.\Delta T$ = 88.07N/mm^2

If a section is 2mm thick and 1000mm girth, the force generated is: -

$\alpha.E.\Delta T.A$ = 88.07 x 2 x 1000 = 176150N = 176.1kN = 17956kg = 17.96 tonnes

MCRMA member companies can advise on the suitability and performance of materials, systems and assemblies to ensure that aluminium fabrications and flashings are calculated properly and specified accordingly. In addition, design information can be obtained from any of the independent roofing and cladding inspectors featured on the MCRMA web site at www.mcrma.co.uk

DISCLAIMER

Whilst the information contained in this guidance document is believed to be correct at the time of publication, the Metal Cladding and Roofing Manufacturers Association Limited and its member companies cannot be held responsible for any errors or inaccuracies and, in particular, the specification for any application must be checked with the individual manufacturer concerned for a given installation.

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