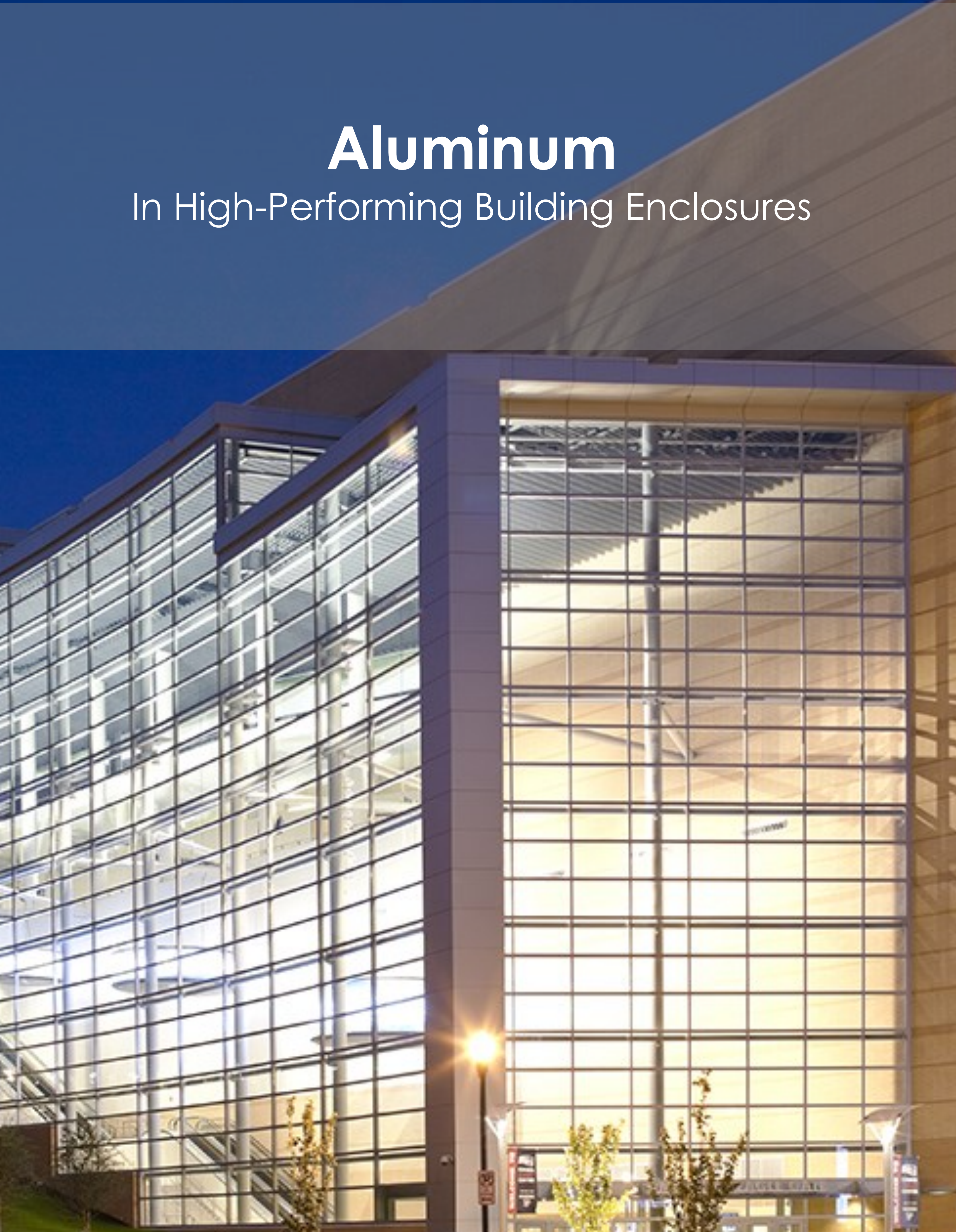
Aluminum

In High-Performing Building Enclosures



Aluminum extrusions used in the manufacture of entrances, storefront framing, curtain walls, windows and skylight fenestration systems play a major role in making high-performing building enclosures more energy efficient and resilient. Commercial buildings account for 18 percent of U.S. carbon dioxide (CO_2) emissions, a primary greenhouse gas, and they consume more than 18 percent, or 18 quads, of U.S. primary energy.[1]

Many types of highly engineered aluminum fenestration systems are designed to meet current and foreseeable stringent energy codes and standards, along with hazard mitigation requirements in earthquake and hurricane prone regions. Additionally, some very striking features of aluminum are its density and strength, yet it is light, highly durable and resists all sorts of challenges to its integrity. As the most recycled metal today, aluminum is 100 percent recyclable at the end of its service life. Almost 75 percent of all aluminum ever produced in the U.S. is still being used today retaining all of its original properties when it is recycled.[2] The recyclability of aluminum benefits both present and future generations by conserving energy and other natural resources. The considerable energy and cost invested in the production of primary aluminum can be reinvested into other aluminum products when aluminum is recycled and used in whole or as part of a new product.

The nature of the extrusion process and the well-organized and cooperative structure of the North American aluminum extrusion industry has ensured consistency during manufacturing from raw material extraction, to production and use, to disposal or recycling and aluminum can meet most complex design requirements.

Over the past 20 years, the North American aluminum industry has consistently improved its processes and reduced the energy consumption, and greenhouse gas emissions, per ton of aluminum produced. According to the Aluminum Association, Life-Cycle Assessment (LCA) the energy needed to produce a single metric ton of primary (new) aluminum has declined 11 percent since 2005 and 26 percent since 1995. The industry's carbon footprint has fallen even more dramatically, declining 19 percent since 2005 and 37 percent since 1995. A voluntary effort undertaken by the industry in the early 1990s with the Environmental Protection Agency (EPA) has reduced emissions of perfluorocarbons (PFC), a greenhouse gas, by nearly 85 percent.[3]

While considered ductile and easy to extrude and machine, aluminum has thermal and electrical conductivity almost as good as copper's making it a poor insulator unless the heat loss pathway is interrupted. Thermally improved aluminum enclosure systems along with auxiliary sunshades, interior light shelves, insulating glazing and metal panel components can work together to significantly reduce operating costs and energy usage. Energy producing photovoltaics may be integrated into many different aluminum assemblies including louvers, shades and awnings incorporated within a building envelope to become electrical energy generators. Solar cells can be incorporated into the fenestration materials of a building, complementing or replacing traditional clear or spandrel glass. Often, these state-of-the-art building-integrated photovoltaic (BIPV) electric power systems installations are vertical, however, access to available solar resources is reduced, but the large surface area of buildings can help compensate for the reduced power.[4] [5]

Aluminum and Green Building

Aluminum fenestration systems in commercial buildings can contribute to green building certification and third-party rating programs in a number of areas, including: energy-efficiency, material sustainability and indoor environmental quality. Green building rating programs were implemented to lessen the ambiguity of green building concepts and practices and have been gaining in popularity over the last two decades. Some municipalities have committed to sweeping changes through their green buildings master plans. Major U.S. cities, such as Washington, D.C., implemented the *Green Building of Act of 2006*, for both the public and private sectors, and Local Law 86 in New York City, where city managed civic or cultural organization are required to use the U.S. Green Building Council LEED (Leadership in Energy and Environmental Design) ratings systems.

LEED is designed to provide building owners and operators with a framework for identifying and implementing practical and measurable green building design, construction, operations and maintenance solutions. Aside from the USGBC LEED green building certification program are the Living Building Challenge (LBC), Green Globes, Passive House Institute US (PHIUS).

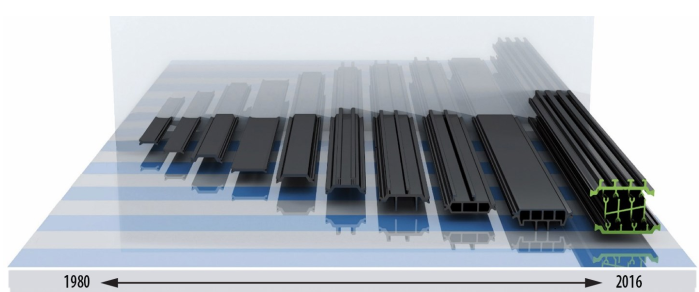
Energy Efficiency

For several decades thermal barriers or thermal breaks have found use in aluminum framing in buildings providing an economical means to help lower energy loss through the enclosure. Manufacturers of aluminum fenestration systems developed and refined thermal aluminum framing systems beginning in the 1970s using thermal barriers as an insulator to lower energy costs and CO_2 emissions.

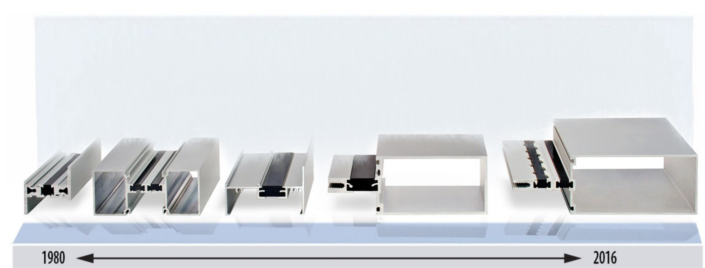
A thermal barrier is an element of low thermal conductivity material placed in an aluminum assembly to reduce or prevent the flow of thermal energy between the interior and exterior of a building. Product and thermal barrier material selection are critical to meeting the different regional thermal performance and catastrophic mitigation and structural requirements.

The advanced thermal barrier systems introduced in recent years are meeting the energy use reduction challenges with better thermal breaks in their design by extending the traditional polyamide struts and offering wide cavity and dual pour and debridged polyurethane thermal barriers.

Progression of thermal barriers

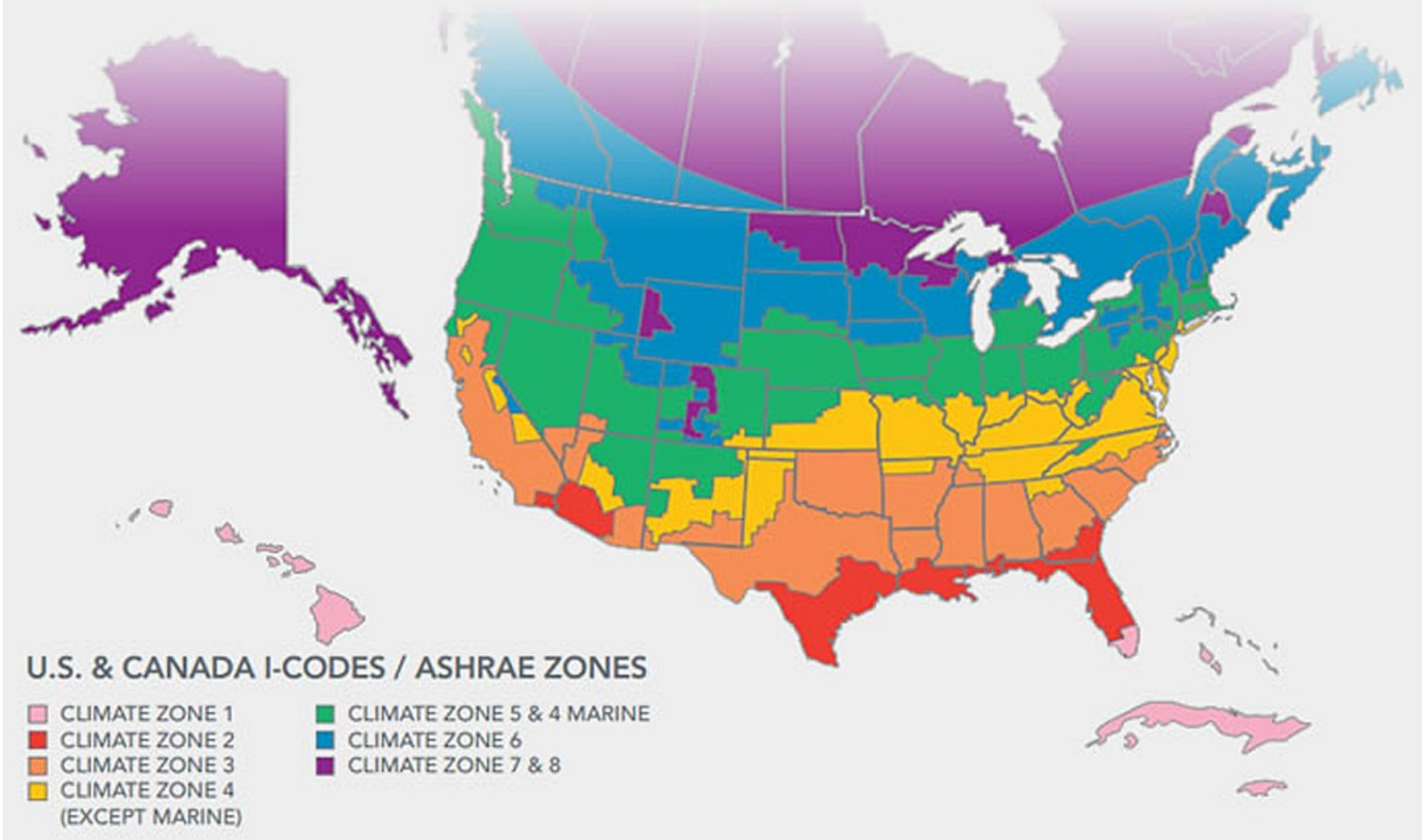


Continual advances and development of higher performance polyamide thermal barrier systems. Courtesy of Technoform.



Continual advances and development of higher performance polyurethan pour and debridge thermal barrier systems. Courtesy of Technoform.

In more recent developments aluminum thermal barrier technology is making further advances—to work in conjunction with glass, glazing and envelope materials—reducing commercial building energy consumption while conserving resources. While a low U-factor is important for aluminum framing in cool climates it is just as important in hot climates due to the high energy costs to cool a building.



Climate Zone and Performance

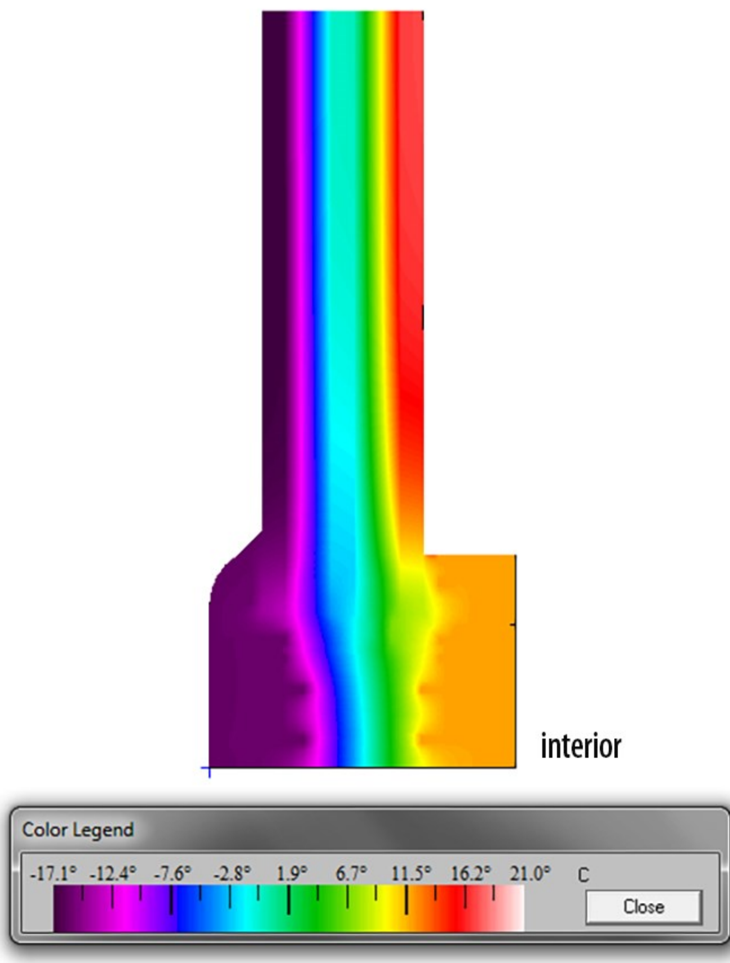
The regional location—or climate zones—of a particular project will determine the minimum thermal performance of an aluminum fenestration system. The International Energy Conservation Code® (IECC) sets minimum energy efficiency provisions for both residential and commercial buildings. The IECC requirements vary by region, which are determined based on the climate and, hence, are called: "climate zones." This map shows thermal performance requirements by climate zones. Image courtesy of Green Zone.

Product Category	Data Source / Zones >	1	2	3	4	5	6	7	8
Nonmetal Framing	2009 IECC + ASHRAE 90.1-2010	1.20	0.75	0.65	0.40	0.35	0.35	0.35	0.35
	ASHRAE 90.1-2013	0.50	0.40	0.35	0.35	0.32	0.32	0.32	0.32
	ASHRAE 90.1-2016	0.50	0.37	0.33	0.31	0.31	0.30	0.28	0.25
	2012 and 2015 IECC	*Same as metal framing fixed or operable*							
	ASHRAE 189.1-2011	1.20	0.75	0.45	0.30	0.25	0.25	0.25	0.25
	ASHRAE 189.1-2014	0.45	0.36	0.32	0.32	0.29	0.29	0.29	0.29
	ASHRAE 189.1-2017 (if 5% proposal passes)	0.48	0.35	0.31	0.29	0.29	0.29	0.27	0.24
	2012 IgCC	*Same as metal framing fixed or operable*							
	2015 IgCC	*Same as metal framing fixed or operable*							
Curtain Wall / Storefront (Metal Framing Fixed)	2009 IECC + ASHRAE 90.1-2010	1.20	0.70	0.60	0.50	0.45	0.45	0.40	0.40
	ASHRAE 90.1-2013	0.57	0.57	0.50	0.42	0.42	0.42	0.38	0.38
	90.1-2016	0.57	0.54	0.45	0.38	0.38	0.36	0.33	0.29
	2012 and 2015 IECC	0.50	0.50	0.46	0.38	0.38	0.36	0.29	0.29
	ASHRAE 189.1-2011	1.20	0.70	0.50	0.40	0.35	0.35	0.30	0.30
	ASHRAE 189.1-2014	0.51	0.51	0.45	0.38	0.38	0.38	0.34	0.34
	ASHRAE 189.1-2017 (if 5% proposal passes)	0.54	0.51	0.43	0.36	0.36	0.34	0.31	0.28
	2012 IgCC	0.45	0.45	0.41	0.34	0.34	0.32	0.26	0.26
	2015 IgCC	0.48	0.48	0.44	0.36	0.36	0.34	0.28	0.28
Windows (Metal Framing Operable)	2009 IECC + ASHRAE 90.1-2010	1.20	0.75	0.65	0.55	0.55	0.55	0.45	0.45
	ASHRAE 90.1-2013	0.65	0.65	0.60	0.50	0.50	0.50	0.40	0.40
	ASHRAE 90.1-2016	0.65	0.65	0.60	0.46	0.46	0.45	0.40	0.35
	2012 and 2015 IECC	0.65	0.65	0.60	0.45	0.45	0.43	0.37	0.37
	ASHRAE 189.1-2011	1.20	0.75	0.55	0.45	0.45	0.45	0.35	0.35
	ASHRAE 189.1-2014	0.59	0.59	0.54	0.45	0.45	0.45	0.36	0.36
	ASHRAE 189.1-2017 (if 5% proposal passes)	0.62	0.62	0.57	0.44	0.44	0.43	0.38	0.33
	2012 IgCC	0.59	0.59	0.54	0.41	0.41	0.39	0.33	0.33
	2015 IgCC	0.62	0.62	0.57	0.43	0.43	0.41	0.35	0.35
Entrance Doors (Metal Framing)	2009 IECC + ASHRAE 90.1-2010	1.20	1.10	0.90	0.85	0.80	0.80	0.80	0.80
	ASHRAE 90.1-2013	1.10	0.83	0.77	0.77	0.77	0.77	0.77	0.77
	ASHRAE 90.1-2016	1.10	0.83	0.77	0.68	0.68	0.68	0.68	0.68
	2012 and 2015 IECC	1.10	0.83	0.77	0.77	0.77	0.77	0.77	0.77
	ASHRAE 189.1-2011	1.20	1.10	0.80	0.75	0.70	0.70	0.70	0.70
	ASHRAE 189.1-2014	0.99	0.75	0.69	0.69	0.69	0.69	0.69	0.69
	ASHRAE 189.1-2017 (if 5% proposal passes)	1.05	0.79	0.73	0.65	0.65	0.65	0.65	0.65
	2012 IgCC	0.99	0.75	0.69	0.69	0.69	0.69	0.69	0.69
	2015 IgCC	1.05	0.79	0.73	0.73	0.73	0.73	0.73	0.73
Skylights, TDDs and Sloped Glazing	2009 IECC	0.75	0.75	0.65	0.60	0.60	0.60	0.60	0.60
	ASHRAE 90.1-2010	1.90	1.90	1.30	1.30	1.10	0.87	0.87	0.61
	ASHRAE 90.1-2013	0.75	0.65	0.55	0.50	0.50	0.50	0.50	0.50
	ASHRAE 90.1-2016	0.75	0.65	0.55	0.50	0.50	0.50	0.50	0.41
	2012 and 2015 IECC	0.75	0.65	0.55	0.50	0.50	0.50	0.50	0.50
	ASHRAE 189.1-2011 w/curb, Glass	0.71	0.71	0.69	0.69	0.67	0.67	0.67	0.58
	ASHRAE 189.1–2011 w/curb, Plastic	1.12	1.12	0.69	0.69	0.69	0.69	0.69	0.58
	ASHRAE 189.1–2011 w/o curb	0.57	0.57	0.45	0.45	0.45	0.45	0.45	0.45
	ASHRAE 189.1-2014	0.68	0.59	0.50	0.45	0.45	0.45	0.45	0.45
	ASHRAE 189.1-2017 (if 5% proposal passes)	0.71	0.61	0.52	0.48	0.48	0.48	0.48	0.48
	2012 IgCC	0.67	0.58	0.49	0.45	0.45	0.45	0.45	0.45
	2015 IgCC	0.71	0.62	0.52	0.47	0.47	0.47	0.47	0.47

During the design process, manufacturers and design engineers can perform thermal modeling or computerized simulation of a fenestration system to ensure the product will meet the U-factors required for the project. Typically, the lower the U-factor requirement of a project, the more complex the thermal barrier design will be in the aluminum extrusion.

Aluminum in commercial fenestration framing requires little maintenance, and when improved with a thermal barrier system, the energy performance and occupant comfort are increased, while simultaneously, the strength, safety and resilience will benefit a building and its occupants for years to come.

Using modeling programs for visualizing infrared heat-transfer analysis and temperature ranges of a thermal barrier window (6) (Lawrence Berkeley National Laboratory).



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(6) Computer thermal graphic (Figure 5): THERM and Window Lawrence Berkeley National Laboratory. LBNL Software Efficiency

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