AL7 TECH

GEORGIAN BAR AT HIGHER THERMAL PERFORMANCE

February 2010

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KEYWORDS: Georgian bar, spacer, warm edge, conductivity, windows, U-value, glazing, linear thermal transmittance, simulation.

Summary

Glazing thermal performance depends on Georgian bars, too, though present regulations tend to neglect this element very popular in Europe, North America and Middle East. As we know windows U-value can be calculated by singles U-values (frame and glazing): thermal transmittance due to the combined effect of glazing, spacer and frame, and thermal transmittance due to Georgian bars.

Spacer producers have developed new products made of materials with higher thermal performance compare to aluminium; ***AL7 MEIPA Srl*** *has likewise introduced its Georgian bar with higher thermal performance:* ***AL7 Tech***[1]*, to create coherence among all double glazing materials.*

In this paper is used a software, validated as per EN ISO 10077-2, to calculate Georgian bar thermal contribution in typical windows applications.

Fixing singles U-values: frame and glazing, range of combinations of thermal contributions given by different kinds of spacers and Georgian bars, suggest to use a matrix. Comparing percentage values of benefits it turns out that differences in thermal contributions obtained by using different kinds of Georgian bars are quite equivalent to thermal contribution of spacers not in aluminium.

These results show that thermal contribution of Georgian Bars should not be neglected and that their natural evolution is started.

Introduction

The big portion of the heat loss in a building is through its windows; even 50% of the total transmission. As a matter of fact, windows thermal performance has been improved in the last few years especially using new materials. This has remarkably increased the range of combinations of products windows are made up of. Because of not all possible combination are included in tabulated values, they are often insufficient to evaluate window thermal performance.

The window-makers use a few kinds of frame profiles but many different glazing units with various edge constructions in their windows. In order to reach the thermal transmittance, it is possible to use typical values according to EN ISO 10077-1 but not all frame profiles and edge constructions can be treated in this way, otherwise too many conservative values are obtained. Regulations, too, have not taken into consideration Georgian bar's contribution at U-Value yet.

The alternative is a detailed finite element software. It can be used to find the linear thermal transmittance of the specific combination of glazing (with or without Georgian bars), edge construction and frame product.

The edge construction of glazing units is made up of spacer profile and sealing. The spacer profile is in aluminium or steel and acts as a significant thermal head. Spacer profiles with improved thermal characteristics have been developed. They are based on thin layers of stainless steel or combinations of polymers and foils of aluminium or stainless steel.

It is interesting to evaluate the single contribution of different kinds of spacers and Georgian bars creating parallelisms between them at total U-value into double glazing: one for spacers and another one for Georgian bars.

[1] Introduced at VITRUM 2009 – Milan; BATIMAT 2009 – Paris

Background

Thermal quality of windows has been recently improved. Thermal performance of most materials windows are made up of has been improved with the exception of Georgian Bars.

The main material of Georgian bar applied into double glazing is aluminium, that achieves all targets required: high performance during process (milling, curving, etc…), a big range of finished, even wood grain finish or anodized, no fogging[2], UV resistance, etc... Other materials, like wood and plastic, are used desultorily and don't reach one or more of these issues.

Unfortunately, aluminium does not have any high thermal performance but stainless steel has; consequently, this is the proper material that better serves the purpose.

AL7 MEIPA Srl proposes **AL7 Tech,** a Georgian bar at higher thermal performance.

Basics

Thermal transmittance or U-value defines the thermal quality of a material or a combination of them. It is the average heat flow through a surface that delimits two spaces with a different temperature.

The U-value refers to a surface and its dimension is $\left[\frac{W}{m^2K}\right]$.

Window thermal transmittance according to EN 10077-1 is calculated by:

$$Uw = \frac{\sum Ag \cdot Ug + \sum Af \cdot Uf + \sum Ig \cdot \Psi g}{\sum Ag + \sum Af} \qquad \text{(a)}$$

where

Ag is the area of the visible glazing

Af is the area of the frame

lg is total perimeter of the glazing; see Fig. 1[3].

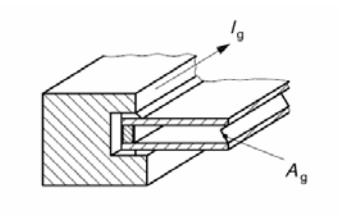

Fig. 1

Ug is the thermal transmittance of the glazing

Uf is the thermal transmittance of the frame

Ψg is the linear thermal transmittance due the combined effect of glazing, spacer and frame

Current Calculation

Once fixed all products as shown in formula (a), the sole value giving a different contribution is the product by the linear thermal transmittance due to the combined effect of glazing, spacer and frame: Ψg and the perimeter of spacer: lg

$$lg \cdot \Psi g$$

[2] Ref. [iii]
[3] Ref. [i]

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having a PVC window with two wings (example A[4]) (Fig. 2) and a PVC window (Fig. 3) with one wing (example (B[5]).

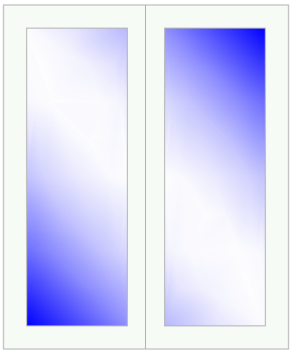

Fig. 2

Geometrical data:

$$Aw = 1.23m \cdot 1.48m = 1.82m^2$$

$$Af = 0.69m^2$$

$$lg = 6.84m$$

Thermal data:

$$Ug = 1.8 \frac{W}{m^2 K}$$

$$Uf = 1.9 \frac{W}{m^2 K}$$

$\left[\frac{W}{m\ K}\right]$	Spacers		
	Aluminium	**Stainless steel**	***"Warm Edge"***
Ψg	0.067	0.050	0.043
lg Ψg	0.458	0.342	0.294
Uw	**2.09**	**2.03**	**2.00**

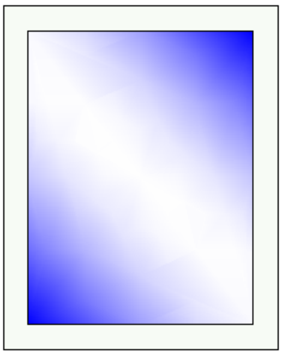

Fig. 3

Geometrical data:

$$Aw = 1.20m \cdot 1.50m = 1.80m^2$$

$$Af = 0.58m^2$$

$$lg = 4.72m$$

Thermal data:

$$Uf = 1.8 \frac{W}{m^2 K}$$

$$Ug = 1.3 \frac{W}{m^2 K}$$

$\left[\frac{W}{m\ K}\right]$	Spacers		
	Aluminium	**Stainless steel**	***"Warm Edge"***
Ψg	0.067	0.050	0.043
lg Ψg	0.316	0.236	0.203
Uw	**1.64**	**1.59**	**1.57**

The absolute values of better performance of "warm edge" or stainless steel spacer compared to aluminium spacer are:

SPACERS	**Stainless Steel Vs Aluminium** $\left[\frac{W}{m^2 K}\right]$	**"Warm Edge" Vs Aluminium** $\left[\frac{W}{m^2 K}\right]$
Example (A)	0.064	0.090
Example (B)	0.045	0.063

Tab. 1 – U-values differences

And in percentage compared to the total Uw values:

SPACERS	**Stainless Steel Vs Aluminium**	**"Warm Edge" Vs Aluminium**
Example (A)	3.63%	5.04%
Example (B)	2.88%	4.00%

Tab. 2 – U-values differences in percentage

[4] Ref. [iv]
[5] Ref. [v]

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Software

As shown in the introduction, it is necessary to use a detailed finite element software. The software used to calculate all results is FRAME SIMULATOR[6], validated in according to EN ISO 10077-2.

To grant reliable results, a finite elements software used for thermal calculations must be validated according to a procedure as described in norm EN ISO 10077-2.

The validating procedure consists of ten projects, described in annex D in the norm, that shall be calculated by the software. Given projects represent different windows frame sections made of various materials and designs:

To pass validation, results from the software shall be within a certain range.

Thus, the calculated two-dimensional thermal conductance L2D shall not differ by more than +3 % from the corresponding values given in Table D.3 and Table D.4 in the norm.

This will lead to an accuracy of the thermal transmittance, U, for the first 9 projects, and of the linear thermal transmittance ψ for project n. 10, of about +5 %.

Frame Simulator has successfully validated all the ten projects given by the EN ISO 10077-2.

The official results of the norm and those obtained with Frame Simulator are compared in the following table:

	Results* according to EN ISO 10077-2:2004		Results with FRAME SIMULATOR		differences **	
	Lf^{2D}	Uf	Lf^{2D}	Uf	Lf^{2D}	Uf
Project n.	W/(mK)	W/(m²K)	W/(mK)	W/(m²K)		
1	0,550	3,220	0,543	3,160	1,3%	1,9%
2	0,263	1,440	0,263	1,446	0,0%	-0,4%
3	0,424	2,070	0,425	2,085	-0,2%	-0,7%
4	0,346	1,360	0,345	1,353	0,3%	0,5%
5	0,408	2,080	0,404	2,042	1,0%	1,8%
6	0,659	4,670	0,669	4,782	-1,5%	-2,4%
7	0,285	1,310	0,282	1,254	1,1%	4,3%
8	0,181	1,030	0,182	1,030	-0,6%	0,0%
9	0,207	3,640	0,206	3,620	0,5%	0,5%
	Lf^{2D}	ψg	Lf^{2D}	ψ_g	Lf^{2D}	ψ_g
Project n.	W/(mK)	W/(mK)	W/(mK)	W/(mK)		
10	0,481	0,084	0,476	0,080	1,0%	4,8%

Note
*In the Norm an error range is also given, while in this table are reported only the center results.
**Max difference admitted: Lf^{2D} ± 3% ; Uf e ψ_g ± 5%

Fig. 4 – Official results of the norm and those obtained by Frame Simulator

Method

According to EN ISO 10077-1 Annex C, table C.2[7], it is possible to achieve U-value of glazing as per examples hereunder:

Example (A): $$Ug = 1.8 \frac{W}{m^2 K}$$

Double glazing filled with air, 4/12/4 one pane coated glass with an emissivity ≤ 0.1.

Input data: ΔT = 20 °C; 40% HR

[6] www.dartwin.it
[7] Thermal transmittance of double and triple glazing filled with different gases for vertical glazing

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PRODUCTS	Conductivity $\left[\frac{W}{mK}\right]$	Normal Emissivity $[1]$
Standard glass	1.000	0.900
Air	0.031	0.100
LE Glass	1.000	0.040

Tab. 3 – Thermal characteristics of products composing glazing, example A

According to software simulation in the centre of glazing[8], as per defined by NFRC (Fig. 5)

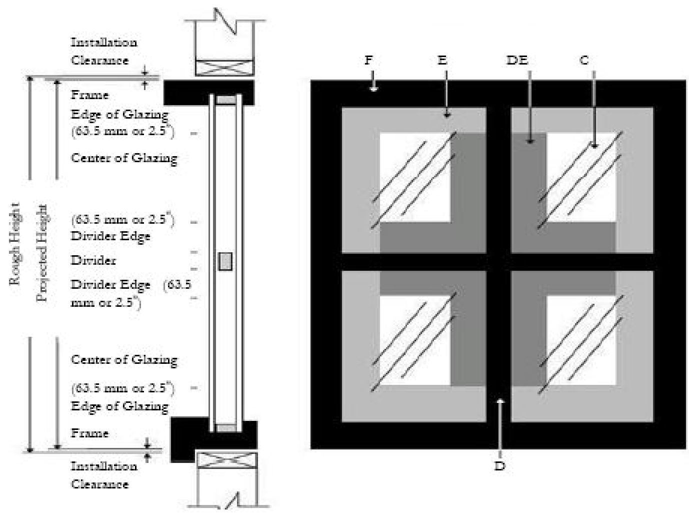

Fig. 5 – Total window assembly

thermal transmittance results:

$$Ug = 1.772 \frac{W}{m^2K} \cong 1.8 \frac{W}{m^2K}$$

Example (B): $$Ug = 1.3 \frac{W}{m^2K}$$

Double glazing filled with krypton[9], 4/12/4, one pane coated glass with an emissivity $\leq$ 0.1.

Input data: ΔT = 20 °C; 40% HR

PRODUCTS	Conductivity $\left[\frac{W}{mK}\right]$	Normal Emissivity $[1]$
Standard glass	1.000	0.900
Krypton	0.018	0.100
LE Glass	1.000	0.040

Tab. 4 – Thermal characteristics of products composing glazing, example B

8 Ref. [vi]; according to The American National Fenestration Rating Council (NFRC)
9 Filling > 90%

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According to software simulation in the centre of glazing, thermal transmittance results[10]:

$$Ug = 1.163 \frac{W}{m^2 K} \neq 1.3 \frac{W}{m^2 K}$$

Introducing two different kinds of Georgian bars[11] (aluminium and **AL7 Tech**), in both cases total linear Conductivity changes:

EXAMPLE	None	Aluminium Georgian Bar	AL7 Tech
A	$LC = 1.772 \frac{W}{m\ K}$	$LC' = 1.802 \frac{W}{m\ K}$	$LC'' = 1.790 \frac{W}{m\ K}$
B	$LC = 1.163 \frac{W}{m\ K}$	$LC' = 1.181 \frac{W}{m\ K}$	$LC'' = 1.176 \frac{W}{m\ K}$

Tab. 5 – Linear Conductivity

Linear Conductivity differences represent linear thermal transmittance: **Ψb**, considering one square meter glazing with one meter of Georgian bar.

$$\Psi b = \Delta LC$$

The following pictures show, through isotherms, typical thermal head of aluminium Georgian bar (Fig. 6) and temperature trend (Fig. 7) of **AL7 Tech**.

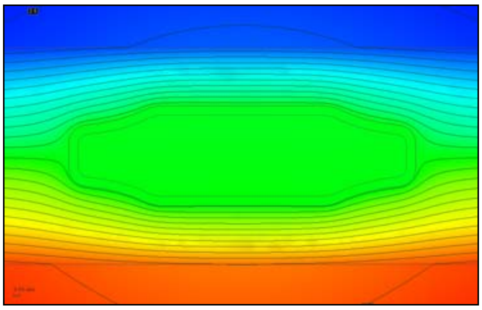

Fig. 6 – Aluminium GB isotherms

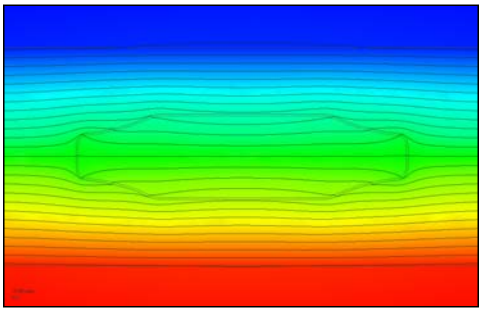

Fig. 7 – AL7 Tech isotherms

Charting temperature values compared to the distance between two extremities of glazing of example A, it is possible to see (Graph. 1) that temperature flows through the glazing.

As in examples temperature difference is 20 °C and relative humidity is 40% HR, from internal and external environments divided by glazing.

Obviously, "none" glazing has a linear trend, and aluminium Georgian bar has a pronounced thermal head. **AL7 Tech** is between them.

[10] Too conservative value that increases unnecessarily costs as underlined in the introduction
[11] Nominal sizes of Georgian bar considered are 26 x 8 mm

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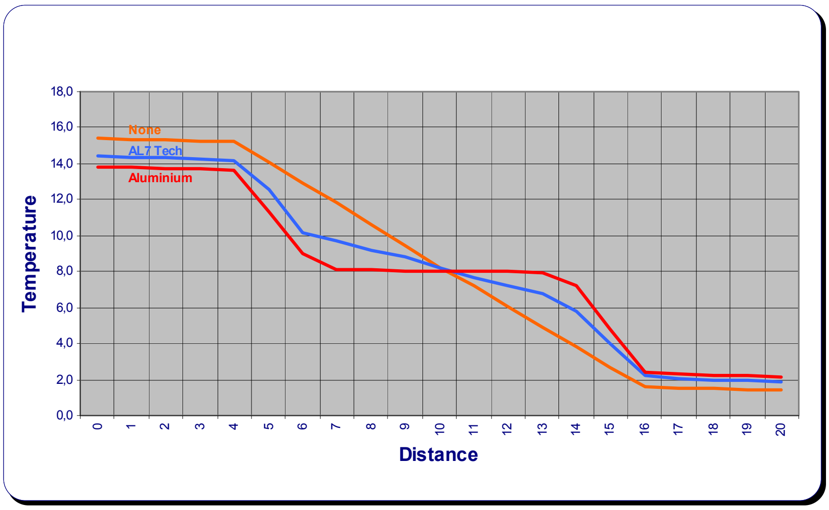
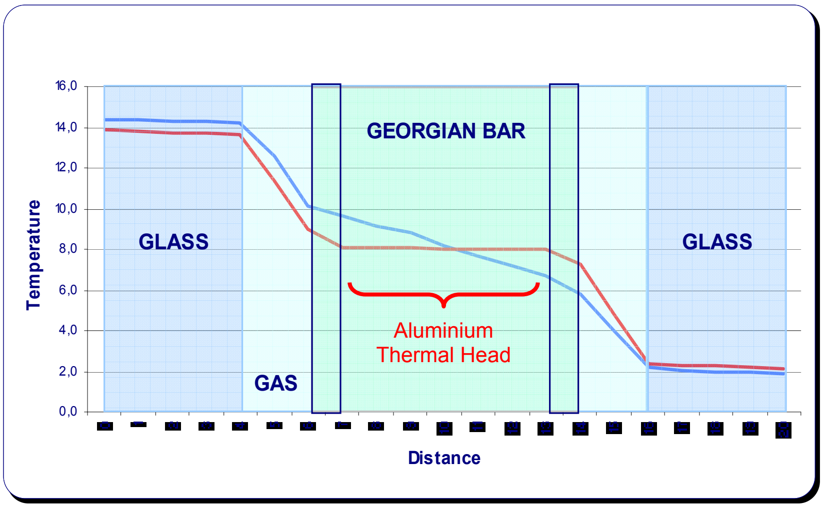


Graph. 1 – Glazing example A: Simple, Aluminium GB and AL7 Tech

Next graphic gives an idea about different thermal heads due to aluminium Georgian bar and **AL7 Tech**. The ramps have different inclinations and flat part covers almost the whole size of aluminium Georgian bar.



Graph. 2 – Flow Aluminium GB and AL7 Tech

To parameterize examples A and B, we have to calculate total length of Georgian bar. Georgian bar grid combinations are various and their length often overcomes spacer length. If we consider a conservative combination of Georgian bars, where they have an inferior (example A) or equal (example B) total length compared to spacers,

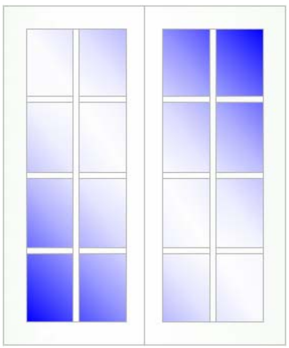


Fig. 8 – GB length inferior to Spacer length

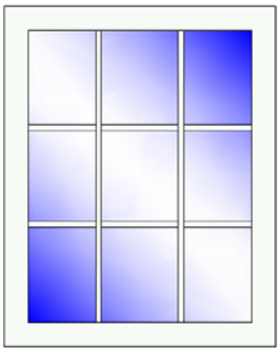


Fig. 9 – GB length equal to Spacer length

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to calculate Uw-value, it is necessary to change formula (a) adding Georgian bar contribution:

$$\sum \mathrm{Ib} \cdot \Psi \mathrm{b}$$

where

Ib is total Georgian bar length

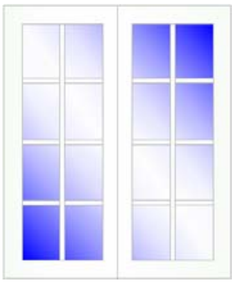
Ψb is the Georgian bar linear thermal transmittance

thus

$$Uw = \frac{\sum Ag \cdot Ug + \sum Af \cdot Uf + \sum Ig \cdot \Psi g + \sum \mathrm{Ib} \cdot \Psi \mathrm{b}}{\sum Ag + \sum Af} \quad \text{(b)}$$

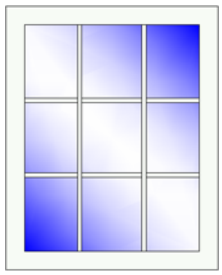
inputting all data as made before and considering ***lb*** values: Ex. (A): $lb = 6.35m$; Ex. (B): $lb = 4.72m$,

Georgian bar linear thermal transmittance is shown as follow:



Ref. Fig. 7

$\left[\frac{W}{m\ K}\right]$	Georgian Bar: Aluminium	Georgian Bar: AL7 Tech
Ψb	0.030	0.018
Ib Ψb	0.191	0.114



Ref. Fig. 8

$\left[\frac{W}{m\ K}\right]$	Georgian Bar: Aluminium	Georgian Bar: AL7 Tech
Ψb	0.018	0.013
Ib Ψb	0.085	0.061

Total benefit is displayed in Table 6.

GEORGIAN BAR	**Stainless Steel Vs Aluminium** $\left[\frac{W}{m^2 K}\right]$
Example (A)	0.077
Example (B)	0.024

Tab. 6 – Total benefit

Fixing Af and Ag, in both example, possible combinations to obtain different U-values are nine.

These combinations are disposed in the matrixes (Tab. 7, 9), where one axis represents different spacers and the other represents different Georgian bars.

GEORGIAN BAR \ SPACER	"Warm edge"	Stainless Steel	Aluminium
Aluminium	2.104	2.130	2.194
AL7 Tech	**2.062**	**2.089**	**2.153**
None	2.000	2.026	2.090

Tab. 7 – Uw-value, example (A)

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Introducing an aluminium Georgian bar in the glazing with warm edge (Uw = 2.106 W/m^2 K) is like to have a glazing with an aluminium spacer (Uw = 2.090 W/m^2 K): all warm edge benefits are lost. **AL7 Tech** (Uw = 2.059 W/m^2 K) helps to reduce meaningfully this gap, maintaining the aesthetics of the windows and consequently of the buildings.

Considering as per 0% the worst combination, thus aluminium spacer and aluminium Georgian bar, the total benefit in percentage is:

GEORGIAN BAR \ SPACER	"Warm edge"	Stainless Steel	Aluminium
Aluminium	4.11%	2.91%	0.00%
AL7 Tech	6.02%	4.82%	1.91%
None	8.95%	7.75%	4.84%

Tab. 8 – Benefit (%), example (A)

Likewise, in example (B) Uw-values are:

GEORGIAN BAR \ SPACER	"Warm edge"	Stainless Steel	Aluminium
Aluminium	1.621	1.639	1.684
AL7 Tech	1.608	1.626	1.671
None	1.574	1.592	1.637

Tab. 9 – Uw-value, example (B)

GEORGIAN BAR \ SPACER	"Warm edge"	Stainless Steel	Aluminium
Aluminium	3.74%	2.65%	0.00%
AL7 Tech	4.52%	3.43%	0.78%
None	6.54%	5.45%	2.80%

Tab. 10 – Benefit (%), example (B)

Conclusions

All products in the market windows are made up of have a higher thermal performance in comparison to the past. Georgian Bars, too, have, even though such potentiality is now neglected by present regulations, but their thermal contribution into double glazing is actually substantial. The several combinations got using different kinds of materials to produce glazing units depend on the right choice of materials that must be coherent with their thermal performance. Stainless steel or warm edge spacers used with aluminium Georgian bars are not the right combination.

AL7 MEIPA Srl has introduced **AL7 Tech**, a Georgian bar that achieves all targets required: high performance during processing (i.e. milling, curving, etc…), a wide range of finishing coats even wood grain or anodized ones, no fogging, UV resistance, and it has an higher thermal performance than aluminium standard Georgian bars and meaningfully reduces U-value, maintaining the aesthetics of windows and thus of buildings.

AL7 Tech is the natural evolution to bring in alignment all elements of I.G. units and to achieve a better thermal performance.

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