Practical Use of Thermal Breaks in Cladding Support Systems

L.B.B. Peer, PhD, PEng

ABSTRACT

Insulation is used to provide thermal separation across building envelopes, however in practice it is almost always bridged by structure, often to surprising extents. The effective value of insulation can be much less than the nominal values specified, and the causes of the devaluation considered inescapable during the course of construction because of trade practices, trade boundaries, assembly sequences, design responsibilities, and plain old inattention. The effects of reduced insulation levels are felt by building owners as purchase cost of ineffective insulation, and operational cost of heating and cooling due to thermal conductance of the envelope.

This paper discusses some tried and true ways, some old, some new, of designing wall assemblies to maximize insulation values, provide gravity, wind, and seismic support to cladding, and realize durable buildings, all within the context of standard construction trade practices. Smarter practices cost less and improve our national energy use statistics.

INTRODUCTION

There are varied reasons for improving energy efficiency in buildings, mostly to do with societal pressures about reduction of energy usage. In temperate wet climates, a consequence of reducing heat flux in buildings is the net reduction in the amount of water that can be removed from a wall. British Columbia, similar to south-eastern and north-western US states, is recovering from the 'leaky building crisis', which could also be called partly the 'effect of reduced heat flux on wood frame construction' crisis. Several billion dollars of renovation work has been carried out on wood-framed buildings that have suffered premature deterioration of wood and steel light framing. Designers and purchasers have discovered that construction methods once commonly used in wood frame construction are not well adapted to buildings in which there is not ample heat (and air) flow through the walls to keep wood dry. Installation of increasing depths of insulation in wood stud framing reduced heat flow to the detriment of drying rates, along with other factors such as wood species not locally grown, plantation wood, and changes in cladding materials, and some would debate, the introduction of vapor barriers into insulated construction. These causes and effects have all been discussed in other places (Chown et al, 2005).

This work addresses a common feature of renovated wall systems, as well as walls used now on commercial new construction, in the wet west coast of Canada. Exterior insulated rain screen wall design moves the vapor barrier (required in climates with sustained vapor drive) to the outside of the light gauge wood or steel stud construction, and installs the insulation, air barrier and cladding outside of the structure. This design features many advantages, effectively moving wood and steel structural framing into inside air (where it enjoys protection equal to the furniture), enveloping all the thermal mass of the building inside the plane of insulation, reducing structural (thermal) penetrations through the air tight and insulated enclosure, and various construction sequencing advantages.

In this method of construction, the structural frame is erected, the building wrapped in its air and vapor barrier (which also serves as an enclosure during construction) and then finishing may begin from inside and outside simulta-

***L.B.B. Peer** is a principal and project engineer with the Building Envelope and Restoration Group at Read Jones Christoffersen Ltd., Vancouver BC, Canada.*

neously. The cladding must obviously be suspended from the structure with sufficient capacity to withstand gravity loads, wind and seismic lateral loads, and gravity and racking deflection of the building. The following typical cladding support schemes for use in 'wood frame' and 'non-combustible' construction types are the subjects of this paper.

The cladding support system in Figure 1 for wood framed construction employs strapping hung from blocking at floor lines, with lateral support provided by stainless steel or screws and nails at specified intervals. In non-combustible construction, light gauge cladding metal supports assembled with thermal spacers hold the cladding through the insulation layer.

Thermal Performance of Cladding Attachment Systems

In this method of construction the opportunity arises to determine how much advantage may be gained by reducing thermal bridging of cladding support structure. This method of cladding support will doubtless also be used to retrofit insulation and cladding in N. American buildings as has begun in Europe. Perhaps if durability, air tightness, and effective insulation are easily achieved, the burden of change will be lessened because of advantages being accrued to owners. Several proprietary systems of improving thermal insulation for buildings exist on the market, and the systems discussed in this paper were developed in response to local construction methods in Canada.

Proprietary Cladding Support Systems Available

Some manufacturers of cladding systems provide proprietary support systems with varying degrees of thermal effectiveness. The common features of these systems are rail systems to support the cladding material, and studs that penetrate the thermal insulation as illustrated in Figures 4 to 9.

Non-proprietary cladding support systems often employ techniques such as girts that cross the plane of insulation. Thermal modelling demonstrates that steel studs intersecting insulation at 16" on centre can reduce effective insulation values to less than 50% of nominal values by thermal bridging.

Modeling

Thermal models were run over a number of years using Frame 4 from Enermodal engineering, Therm 5.1 and Therm 5.2 from LBNL, HEAT3 from Blocon. Typical 2-D Laplace finite difference models are shown in Figures 10 and 11 illustrating base case and Z girt penetration of wall assemblies respectively.

Heat loss due to thermal bridging is similarly high in assemblies where batt insulation is used to fill the stud cavity space. Dew-point and condensation control problems in some residential buildings make this an undesirable practise in most of the coastal and cold regions of Canada. (Hubbs, 2006)

Prototypes and Systems

This work has modelled various methods of decreasing thermal conductivity through insulation planes in insulated wall assemblies. Two main construction types are wood-framed buildings with wood overcladding, and wood and steel framed buildings with light gauge steel overcladding. Examples of such assemblies are shown in Figures 1, 2, and 12.

The system in Figure 12 uses ¼" HDPE thermal breaks between the 4" x12 gauge clips, and a 2 x 2 x 16 gauge rail. Hat sections mounted at 24" o.c. support the cladding and form the drainage cavity air space outboard of the insulation.

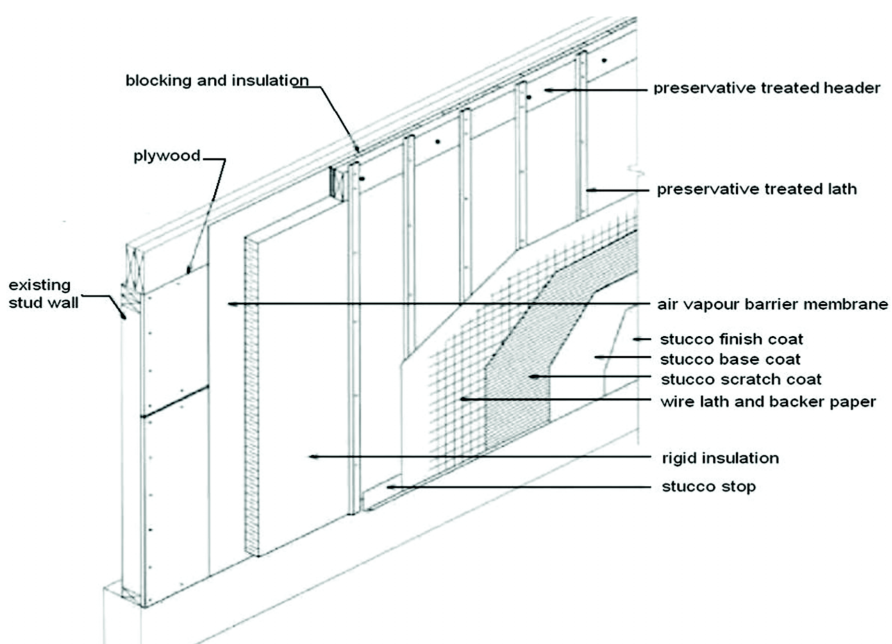

Figure 1 *Schematic of wood-framed wall with air vapor barrier membrane, external insulation, and cladding support system.*

Table 1. Typical Thermal Conductivity Calculations for Various Assemblies Showing Degradation of Insulation by Thermal Bridges*

Case	Wood Frame Steel Frame	Girt Spacing	U-Factor (W/m^2·K)	% Effective
A	Wood	None	0.3196	100
B	Wood frame wood clad Z girts cladding support	24	0.4836	66
C	Steel frame, stucco clad, Zgirts cladding support	16	0.7003	45
D	Steel frame, stucco cladding, Zgirts cladding support	24	0.5734	56
E	Wood Frame, wood blocking through insulation	16	0.3524	91

* Thermal models similar to Figure 10.

Figure 2 *Steel stud wall, sheathed with air-vapor barrier membrane, and layout of cladding support clips prior to insulating.*

Figure 3 *Roof wall glazing interface showing airtight assemblies under construction. Note parapet steel offset on stubs.*

Calculations of wood frame wall systems with external insulation and wood strapping schemes nailed on indicate overall effectiveness on insulation of between 98 and 99% depending upon the number of fasteners used and the cross section of wood blocking mounted through the insulation. Wood blocking methods range in effectiveness between 87% and 93%. Variables included nail spacing, strap spacing, and use of wood blocking. The nail and strap spacing has negligible effect on insulation values, while the use of wood blocking in the plane of insulation does degrade insulation values.

Calculations made with 2-D and 3-D thermal modelling programs indicate that use of clips and rails can reach better than 90% of effective insulation values. Reducing the number of rails by increasing rail spacing and steel gauge is seen to have the most effect on insulation effectiveness, followed by similarly increasing clip spacing. Use of stainless steel clips had a small effect on improving thermal performance, as did varying the thermal spacer material and thickness.

As insulation levels increase, thermal degradation from steel penetrations increases in proportion to insulation value. When insulation thickness is doubled from 3” to 6”, the effect of the thermal penetration is more damaging than at lower insulation levels, in essence the bridges grow in importance as insulation levels increase.

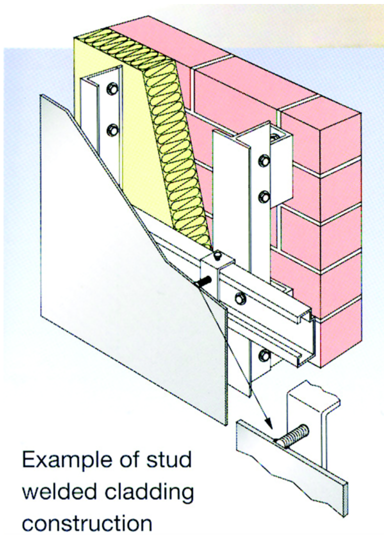

Figure 4 *Alcan (Europe) stud-mounted cladding on two-way rail system.*

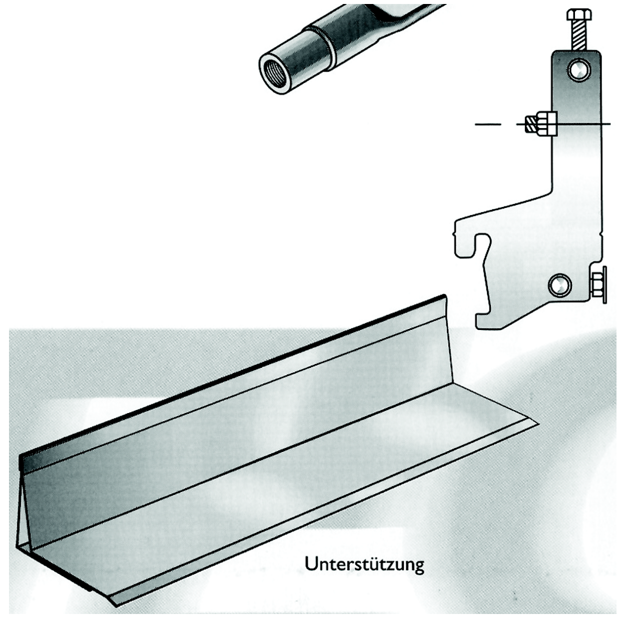

Figure 5 *Hakron TEQ stainless-steel shelf angle.*

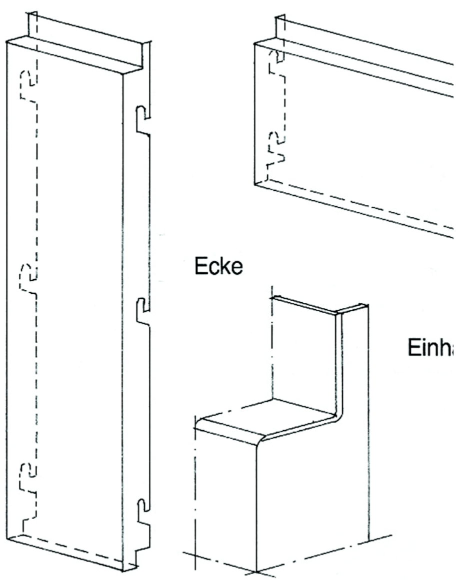

Figure 6 *Cassette cladding panel supports (VAK Bau-Profil and others).*

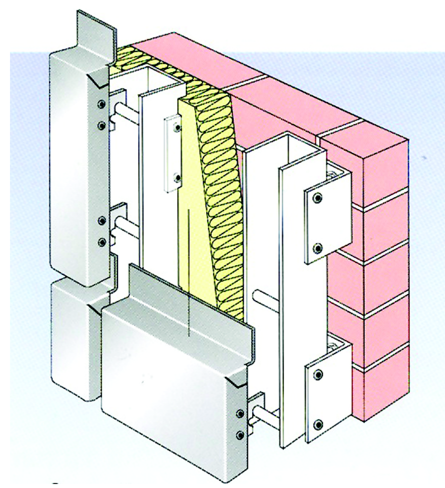

Figure 7 *Cassette cladding panel supports Alcan Europe.*

SUMMARY AND CONCLUSION

Wood strapping and blocking schemes have generally high thermal efficiencies, higher than light gauge systems, however 98% insulation efficiency can be achieved by both methods with adequate care over detailing.

Wider spacing of thermal penetrations is more effective than incorporating thermal isolators in cladding support systems. Commercial cladding support products using widely spaced clips penetrating through insulation can be believed to have the greatest thermal efficiencies.

Use of thermal breaks is more important as thermal insulation values are increased. Law of diminishing returns dictates that increasing thickness of insulation beyond 3" without thermal breaks in cladding support is relatively ineffective. Thermal penetrations reduce local surface temperatures of interior surfaces resulting in potential moisture problems.

Construction experience indicates that incorporating thermal breaks, particularly in cladding mounted over concrete construction, assists cladding installers with alignment over untrue structural assemblies, and saves materials and time by installing fewer penetrations. The methods do increase cladding erection time slightly be requiring more complex layout measurements on the wall surface by the installers. Use of back

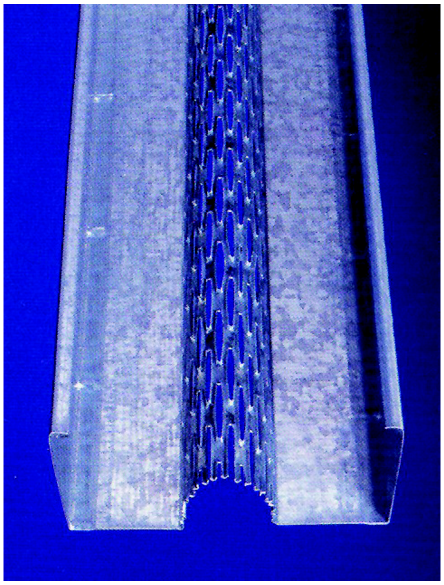

Figure 8 *Steel stud with sound and thermal break by Profil Vertrieb.*

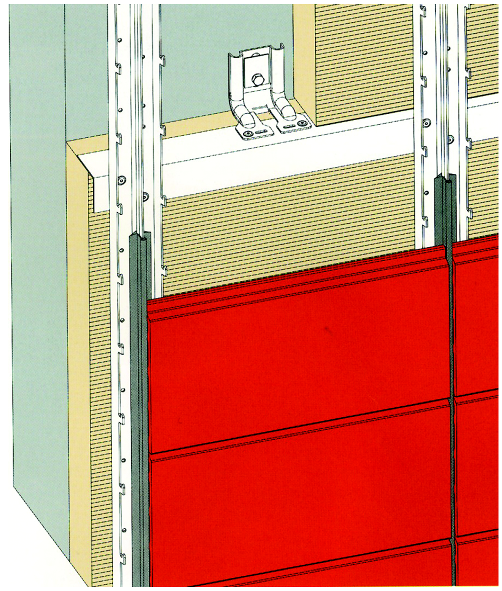

Figure 9 *Terra cotta cladding support by Creaton AG.*

to back angles represents less change of practise but also higher heat loss than using clips. Use of stainless steel has dual advantages, in resisting corrosion for long service life applications, and in reducing thermal transfer through cladding support because of its lower thermal conductivity.

In the author's experience cladding support design by trade shop drawings does not result in changes to practise since simple designs are continuously recycled in the commodity engineering market. Specifications requiring widely spaced clips angles and girts, thermal spacers and stainless steel do transform cladding installation practises while allowing the installers latitude to develop or purchase cladding supports.

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Posey, J., Dalgliesh W. A., 2005 Thermal Bridges – Heat flow models with HEAT2 HEAT3, and a general purpose 3-D solver. *10th Canadian Conference on Building Science and Technology, Ottawa, 2005.*

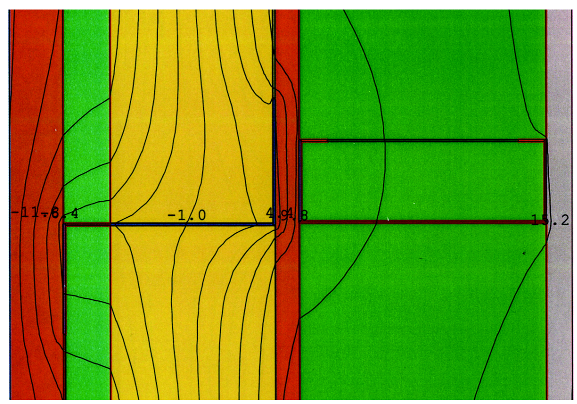

Figure 10 *Thermal model of Z girt penetration of insulation over wood construction.*

ASHRAE 2005 Handbook - Fundamentals *American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 2005.*

National Research Council of Canada 1995 *Canadian National Energy Code for Buildings*.

ANSI/ASHRAE/IESNA Standard 90.1-2004 Energy standard for buildings except low-rise residential buildings. *American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. 2004 ISSN 1041-2336.*

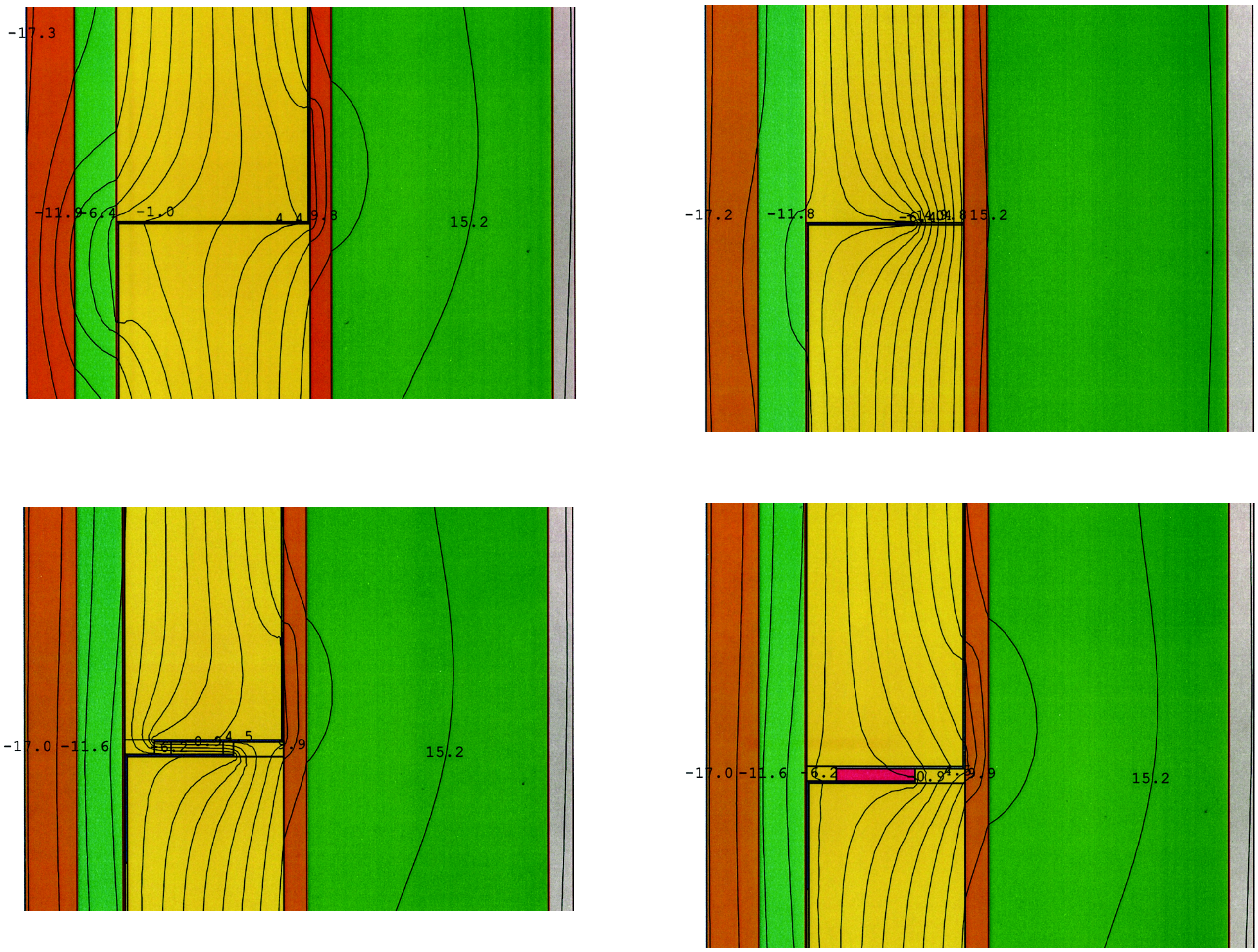

Figure 11 *Thermal models of Z bar configurations with (a) no thermal break, (b) and passing part-way through insulation, (c) back-to-back angles, and (d) angles at an HDPE thermal spacer.*

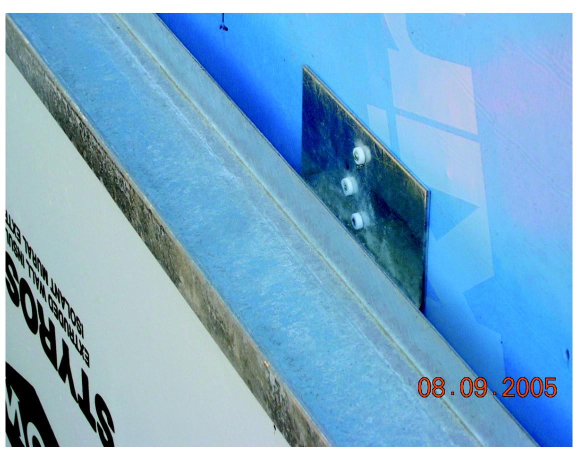

Figure 12 *Light gauge steel cladding support over air and vapor barrier membrane on gypsum wallboard sheathing over light gauge steel framing.*

Table 2. Typical Insulation Effectiveness with Wood Strapping over 102 mm Extruded Polystyrene Insulation on Wood-Frame Construction*

Case	Nail Spacing mm (inches)	Strap Spacing mm (inches)	Block Spacing mm (inches)	U-Factor ($W/m^2.K$)	Insulation Effectiveness (%)
N	None	None	None	0.2582	100
P	610 (24)	610 (24)		0.2587	99.80
Q	305 (12)	610 (24)		0.2600	99.32
R	305 (12)	305 (12)		0.2618	98.64
S	610 (24)	305 (12)		0.2592	99.60
T	610 (24)		610 (24)	0.2770	93.20
U	305 (12)		610 (24)	0.2779	92.92
V	305 (12)		305 (12)	0.2976	86.77
W	610 (24)		305 (12)	0.2959	87.27

* Typical model in Figure 13.

Table 3. Effectiveness of 3” Extruded Polystyrene Insulation with Various Light Gauge Metal Clip and Rail at Reducing Thermal Penetrations*

Case	Clip Spacing mm (inches)	Rail Spacing mm (inches)	U-Factor ($W/m^2 \cdot K$)	% Effective
A1	None	None	0.3196	100
B	610 (24)	610 (24)	0.3589	89
C	610 (24)	1220 (48)	0.3392	94
D	407 (16)	1220 (48)	0.3433	93
E	508 (32)	1220 (48)	0.3260	98
F	Double continuous angle spacers 610 (24)	610 (24)	0.3631	88
G	Stainless 610 (24)	1220 (48)	0.3373	95

* Models geometries shown in Figure 11.

Table 4. Influence of Insulation Thickness and Thermal Bridging on Insulation Effectiveness

Case	Insulation Thickness, mm (in.)	Rail Spacing, mm (in.)	U-Factor, $W/m^2 \cdot K$	% Effective	% Effective Relative to Case A1
A1	75 (3)	None	0.3196	100	100
A2	75 (3)	610 (24)	0.4704	68	68
H1	101 (4)	None	0.2597	100	123
H2	101 (4)	610 (24)	0.3922	66	82
J1	152 (6)	none	0.1821	100	175
J2	152 (6)	610 (24)	0.3176	57	101

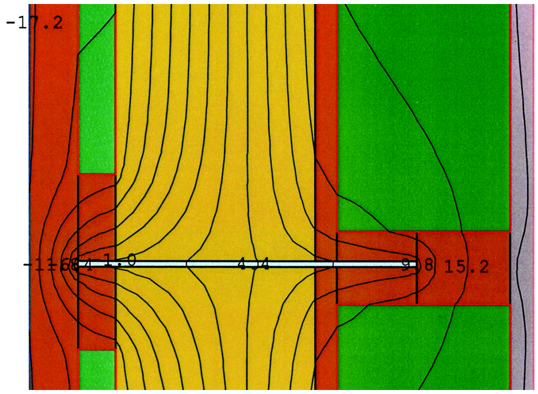

Figure 13 *Thermal model for Table 2.*

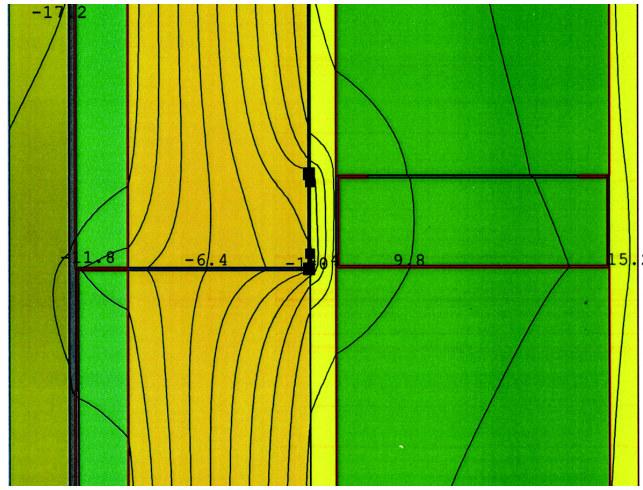

Figure 14 *Thermal model for Table 4.*