Compact Superinsulated Wall & Roof System Featuring AURA® Superinsulation Panels

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A concept is presented that proposes a novel technique for employing vacuum insulation panels in the wall & roof assemblies of residential buildings requiring a high level of thermal insulation.

This paper discusses the merits of the proposed wall system including reference to the materials employed and the installation techniques required to utilize the system in building construction.

The wall arrangement has been designed to deliver a thermal insulation performance under general climate conditions that would be equivalent to an overall steady state thermal resistivity of R30. This level of performance has been modeled using a two dimensional steady state computer model originally developed for predicting the performance of AURA® Superinsulation in residential refrigerators.

INTRODUCTION

Current types of thermal insulation employed in traditional wood framed building construction reflect the fact that basic assembly methods have changed little in recent times. A limited amount of modular or pre-engineered systems have gained some acceptance, but in the main these so called ''modular'' systems differ only marginally from field assembled structures.

The most radical departure from traditional construction methods has been found with ''stressed skin'' foam systems. These systems differ from conventional wood framing in so much that they utilize rigid foam not only as a thermal insulation, but also as a structural component.

The concept described in this paper utilizes a rigid vacuum insulation panel as an integrated structural component, but unlike the stressed skin approach, this wall system also features wood stud type framing. The basis for the use of wood stud framing is the assumption that such an assembly would readily accept existing sheathing or cladding materials, using conventional wall fastening and construction practices.

GENERAL DESCRIPTION OF THE VACUUM INSULATION PANEL

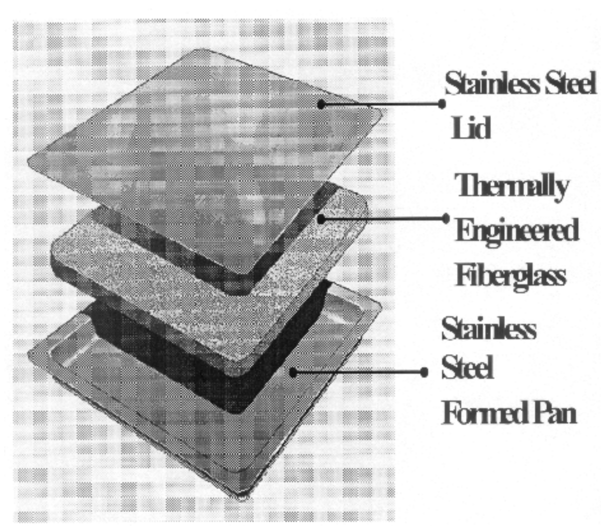
The vacuum insulation panel referred to in this paper is Owens-Corning's AURA® Superinsulation, (see Figure 1) which consists of a thermally engineered glass fiber media encapsulated in a welded stainless steel shell.

This panel was primarily designed for use in residential refrigerator applications, where stable thermal performance over a long product lifetime is of paramount importance. The selection of stainless steel as an encapsulation material makes this life expectation a more realistic proposition.

It is also worth noting that the panel contains no ozone-depleting chemicals, and the materials used in its construction are readily recyclable.

These attributes make the product an excellent candidate for use in future building designs requiring exceptional levels of thermal insulation.

Figure 1. *Basic Construction of the AURA® Superinsulation Panel*



PANEL MANUFACTURE

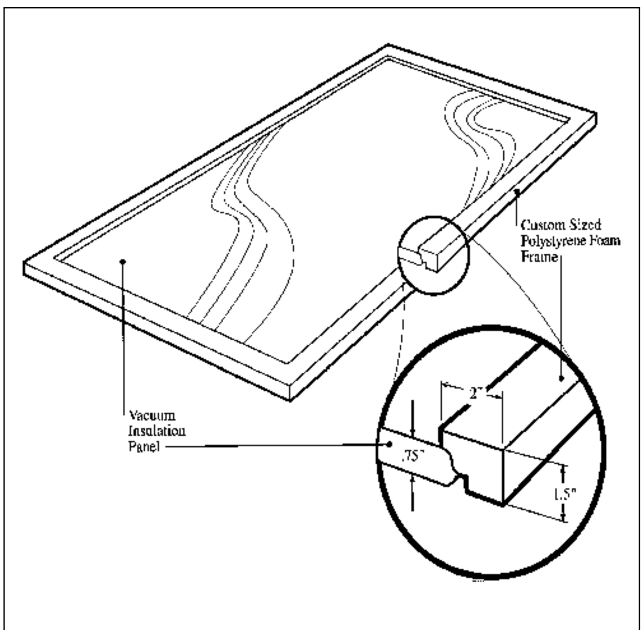
Currently AURA® Superinsulation is manufactured and supplied as a flat panel in a range of sizes depending upon application. In addition to a basic panel, the product can also be supplied with certain enhancements to facilitate customer use, such as pressure sensitive adhesive, and various pre-assembled polystyrene foam arrangements, including the particular foam frame enhancement featured in this paper. A typical configuration of foam frame and vacuum panel is shown below (see Figure 2). Essentially the arrangement consists of a polystyrene frame section bonded directly to the perimeter of the vacuum panel. This frame is typically custom sized and profiled to meet the need of a specific application.

In the case of the ''compact wall system'', the customized frame significantly extends the utility of the basic panel by providing a edge detail that can be located directly into the supporting engineered wood studs. In general use the frame also serves to overcome the thermally deleterious edge effects associated with the panel's stainless steel shell, by providing a supplemental thickness of insulation around the panel perimeter.

INSTALLED THERMAL INSULATION PERFORMANCE OF THE FRAMED PANEL

To date AURA® Superinsulation has been primarily used in applications related to the residential refrigerator industry.

Figure 2. *Typical Arrangement of Framed Panel*



To gain acceptance, this has involved extensive in-situ trials with most of the world's major refrigerator manufacturers. These trials have comprehensively confirmed that the installed performance of the product can be twice as effective as other forms of vacuum insulation and five times more effective than urethane foam, (see Figure 3.).

In addition to physical testing, there has also been a significant body of work directed towards the creation of a computer modeling program designed to reliably predict the thermal insulation performance of enclosures incorporating AURA® Superinsulation panels.

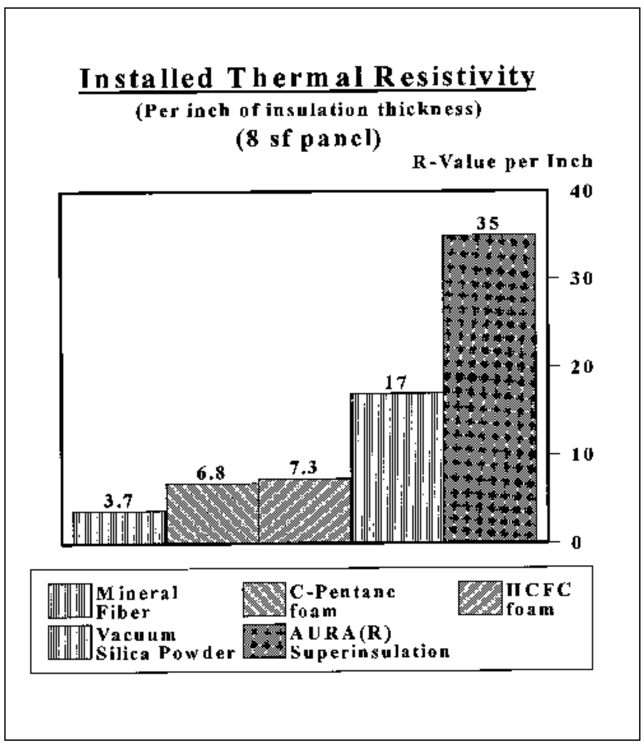
This computer model was utilized to help design the wall arrangement featured in this paper, and to specifically define the required frame geometry to generate the targeted R30 performance rating.

DESIGN OF COMPACT WALL SYSTEM

Design Criteria

The experience gained in the work involving the refrigerator industry has shown that the full potential of the vacuum insulation panel is best realized if the product is installed in a new refrigerator designed specifically for vacuum insula-

Figure 3. *Measured Installed Thermal Insulation Performance of AURA® Superinsulation*



tion usage, rather than attempting to fit into designs based upon the use of urethane foam materials. This approach was therefore adopted in the development of the design of the proposed compact wall assembly, and the following criteria were employed as indicated:

- Effective overall thermal resistivity of the wall system should be nominally R30. This was achieved through a combination of panel size, and polystyrene frame geometry;
- Actual wall assembly should be amenable to either current field or factory assembly techniques. The engineered stud provided the solution;
- Any arrangement must provide adequate puncture resistance for the AURA panel. The design incorporates a 0.75 inch thick layer of polystyrene foam on the outside of the panel;
- Final assembly should be compatible with existing sheathing or cladding materials, and fixing methods. The selection of a wood based engineering stud satisfied this requirement;
- The basic design would be built around a nominal 2″ × 4″ wall section to ensure that the system would interface with standard door and window components. This requirement was met through appropriate sizing of panel and polystyrene foam frame.

REVIEW OF FINAL ARRANGEMENT

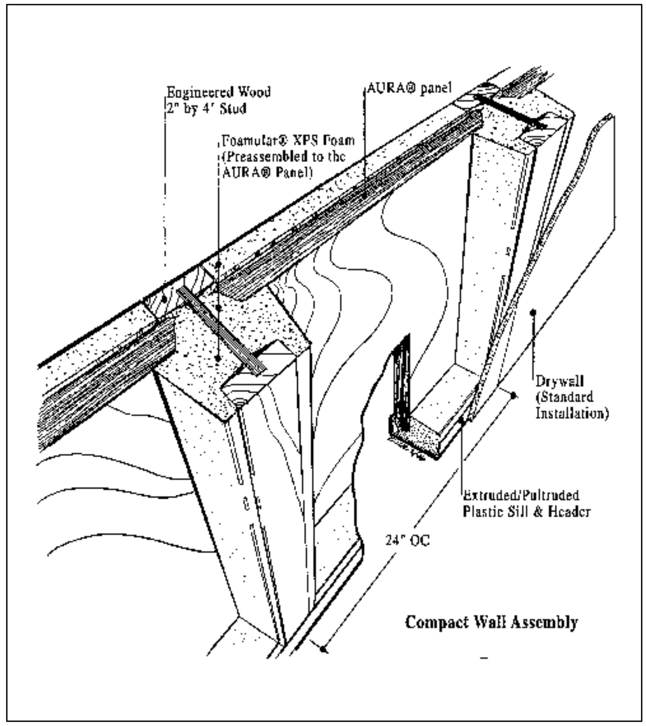
The proposed scheme is shown in Figure 4), and the main components are:

- Framed vacuum insulation panels.
- Engineered wood studs equivalent in size to a regular 2″ × 4″ wood stud.
- Sill & Header pieces constructed as channel sections using regular extruded/pultruded plastic composite materials.

Noteworthy features of this assembly include:

- The assembly could be erected using straightforward mechanical fixing.
- Use of channel sections for the sill & header, simplify location and fixing of the engineered wood studs.

Figure 4. *Compact Wall Assembly*



- The framed panel provides a cavity behind the drywall which could accommodate service components such as electrical or water systems.
- The system has the flexibility to be assembled as either a permanent or a temporary structure.

APPLICATION OF CONCEPT TO CURRENT DAY CONSTRUCTION

It is envisaged that this compact wall system would in the first instance find employment in those applications requiring an exceptional level of energy efficiency. performance specification. The ease of assembly and even disassembly may also offer additional opportunities particularly for temporary housing structures used for example in harsh climates.

The hurdles that must be overcome to gain acceptance include:

1. Cost

Typically the cost that traditional builders are concerned with would be the first time purchase price of the components used in the wall assembly. To gain acceptance for this system the builder would also have to factor on assembly costs and a comparison of total costs of alternative assemblies with equivalent performance, built using existing insulation materials. It is anticipated that some cost advantage would be obtained from the opportunity to use standard door and window components.

It is therefore not unreasonable to assume that even though vacuum insulation panels are more costly than traditional materials on a square foot basis. In terms of complete system cost, a structure built using the compact wall system could challenge other high performance wall systems.

2. Industry Acceptance

Positioning this as a pre-engineered arrangement, the appeal of the compact wall system could be quite high. Although not viewed as a complete substitute for wood framed fiberglass or foam insulated wall assemblies, built-in larders or energy-efficient sunrooms could present a market opportunity, possibly in the form of a ready-to-assemble building kit. In addition the concept could be an ideal system to employ in super energy efficient construction, particularly for use in harsh or extreme environments.

On a practical level industry acceptance should not be hampered by requirements for special training or new finishing technologies, because the concept has been designed to accommodate all existing sheathing or cladding materials, and regular fastening methods.