Designing Your Appliance for Optimum Thermal Performance

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Appliance engineers have many elements to consider when designing new models. Unfortunately, the answers for many of these thermal questions come too late. Neglecting thermal performance in the initial design phase can result in less than ideal solutions, bandage fixes, difficult to manufacture/assemble solutions, and higher final costs.

Perhaps the lack of emphasis given to optimizing insulation comes from a perception that all insulations are "created equal" and does not provide a "marketable" advantage. **Lydall knows differently and has the data to support it.** Could you market a larger cavity? a cooler surface? more energy efficient? a smaller footprint? the best "value" appliance? a better self-clean? fewer service calls? a more environmentally friendly appliance? **Chosing the right insulation is a critical component in achieving these goals.**

Thermal resistance

The most critical physical property of an insulating material is the k-value, or thermal conductivity. Quite often, people refer to insulation efficiency by R-value. R-value is simply a function of material thickness(t) and k-value(k) where: R=t/k. However, understanding the k-value is more important when considering high temperature insulation material options. Figure 1 demonstrates the

Some heated questions for appliance manufacturers:

- How often do you think about the effects of insulation and the overall thermal performance of your appliance?
- What materials are available?
- What material(s) make the most sense for your application?
- Have we considered thermal design trade-offs?
- Is there an expert to help?
- Do we know what partners are available?

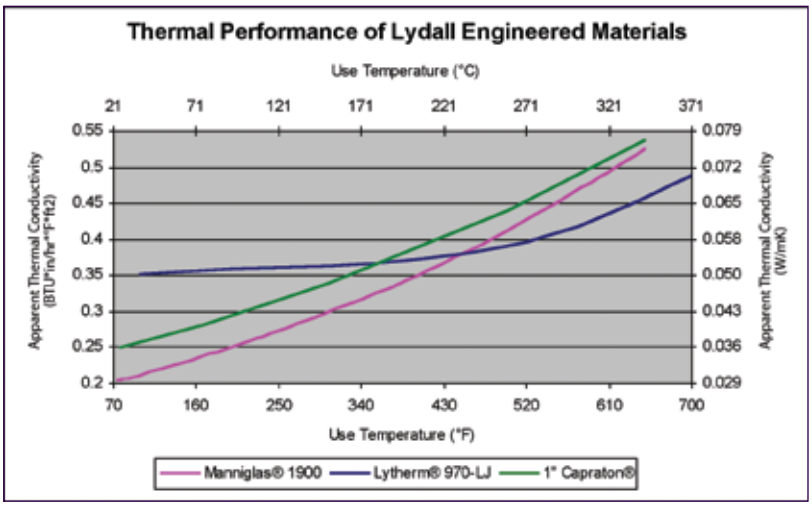


Figure 1: Thermal Performance of Lydall Engineered Materials

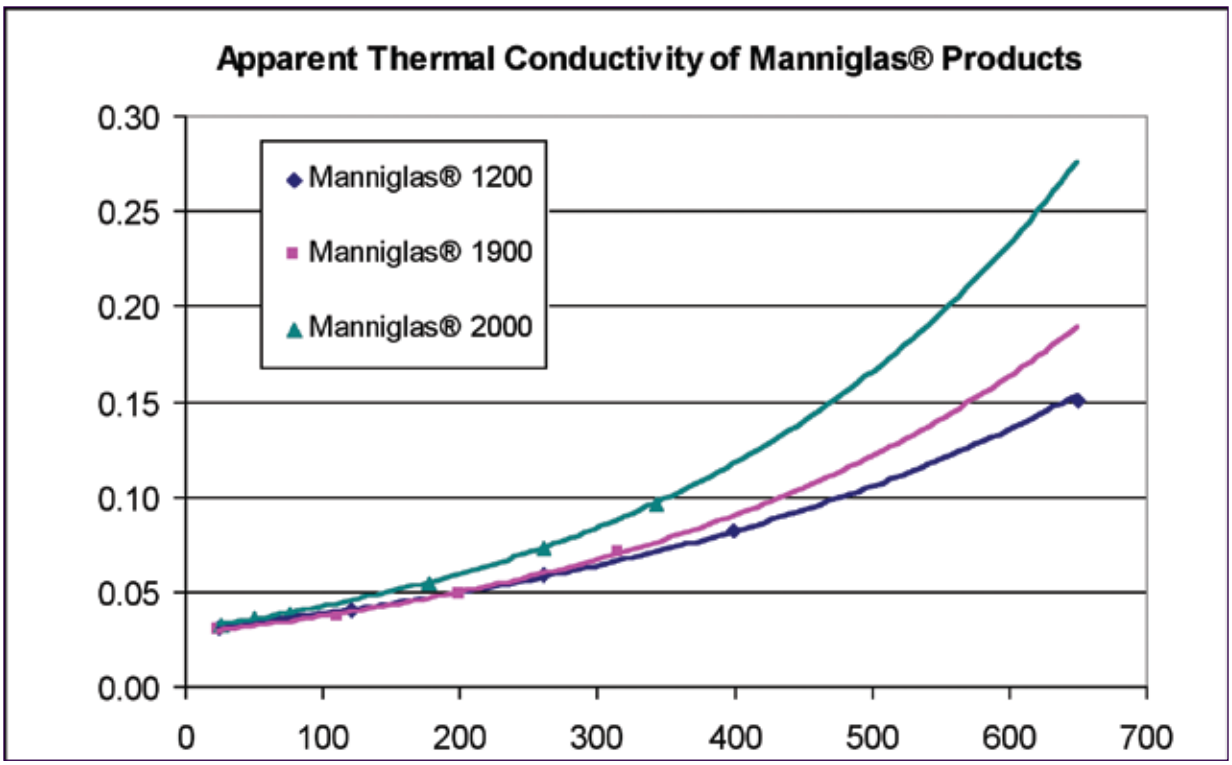


Figure 2: Impact of fiber diameter on the k-value of Lydall Manniglas® products.

k-value of various Lydall Engineered Materials at different temperatures. Note that the lower the k-value, the better the insulating property. The material chosen will vary based on the application temperature.

So what affects the k-value of a material? Insulations work by holding air still and blocking infrared heat transfer. Physical properties such as fiber diameter, density, and product uniformity – which are often overlooked – will impact k-value, hence thermal performance of an appliance. Figure 2 illustrates the extent to which fiber diameter can impact k-value.

The primary difference between these Lydall materials is fiber diameter, where Manniglas® 1200 has the smallest and Manniglas® 2000 the largest. Notice that as the fiber diameter decreases, the k-value correspondingly decreases, consequently improving the thermal performance. Therefore, understanding k-value is one element of enhancing appliance performance.

Insulation… beyond k-value!

Although k-value is a critical physical property, there are many others factors that determine and drive material selection. These include but are not limited to: use temperature, handling needs, health & safety requirements, ease of use/assembly, long term durability, compression resistance, recycling needs, and of course, cost.

Having an insulation partner that understands material properties… the impact of these materials in appliance applications… has a broad range of materials available… and is continuously developing materials to meet the growing demands of the appliance market… is critical.

As an example, insulation “fit and form” can have a more significant impact on the final solution than k-value. Installation

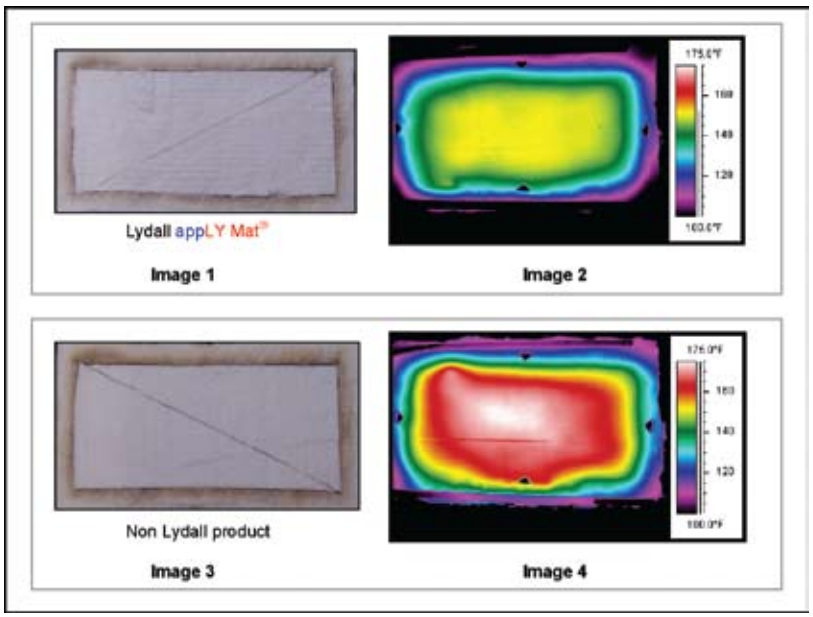


Figure 3: Thermal imaging demonstrates the impact of density and insulation fit on surface temperature

Note: These images were obtained by an in-house Certified Thermographer at Lydall's dedicated Appliance Laboratory.

issues such as improper seaming, sagging, and over-compression can wreak havoc on the thermal performance. Figure 3 demonstrates the impact that insulation density and compression resistance have on the surface of a heat source, for example, the surface temperature of an oven.

In Figure 3, the effect of seaming is illustrated. The images on the left show the insulation installation, whereas the images on the right show the resulting surface temperature distribution using IR thermal imaging. Image 1 shows two pieces of appLY Mat®, seamed diagonally, on a hot surface. Image 2 is a thermal image of this arrangement and demonstrates the invisibility of the seam, as well as the uniform reduction and distribution of heat across the surface. For an oven or range application, this is exactly the kind of performance that is necessary.

Image 3 shows the installation of a non-Lydall material. In Image 4, the higher temperatures indicated by the areas in white are a result of poor physical characteristics of the insulation and are evident along the seamed area.

The impact of density and compression resistance is evident when comparing Image 2 and Image 4. Image 2 shows an overall cooler surface when compared to Image 4, primarily attributed to a higher density material. Additionally, the seam using appLY Mat® is virtually invisible thermally as compared to the non-Lydall material with poor compression resistance, where the seam could result in a "hot spot". A poorly cut

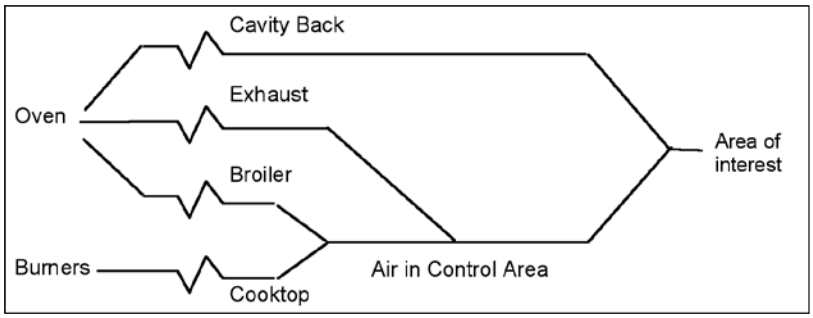


Figure 4: Potential heat paths and heat transfer mechanisms

seam can also result in this type of heat loss, which can be magnified with a product with inadequate dimensional stability. When considering the assembly process, these physical properties can have significant impact in the overall appliance performance.

Overall design

Another critical element to consider is the overall unit design and the impact that different materials can have when tailored to the heat source. Understanding and developing a thermal solution requires that one understands the thermal operation of the entire unit, including the type of heat source, the air flow, the conduction, radiation, etc. As an example, a broiler area with high infrared may best be served by a reflective insulation such as AMS®. Referring to Figure 4, if the broiler is the main source of failure, insulating the cavity back will have little impact on the area of interest.

To develop a thermal solution, the fundamental design element should be considered in conjunction with an understanding of the basket of thermal materials available.

Engineered Materials

Lydall is committed to providing the appliance industry with Engineered Insulation Materials via a broad product offering and technical expertise that is outstanding in the industry. We are continuously designing materials that can help achieve the complete design parameters of your appliance. Consider some of the materials commercially available:

appLY™ Mat -
insulating mat manufactured with non-respirable fibers used to improve energy efficiency and reduce surface temperatures —available in **low odor** and odorless versions while maintaining excellent physical strength and thermal performance

Manniglas® -
an industry standard in gasket applications that helps reduce heat loss and air leakage, protect critical components and reduce surface temperatures in narrow spaces – manufactured using **non-respirable** fibers

BioTherm -
a **biosoluble**, high temperature paper, also used as gasketing to reduce thermal losses and to provide thermal protection where temperatures exceed 1100°F—part of the LyTherm® family of high temperature paper products

AMS® -
patented all-metal heat shield that is fiber-free and **fully recyclable**

All these materials have unique attributes and should be considered early in the design phase. Additionally, Lydall Engineered Insulation Materials are RoHS compliant and we work closely with appliance design engineers/manufacturers to understand the impact of WEEE requirements on appliances.

Engineering reliable insulation solutions

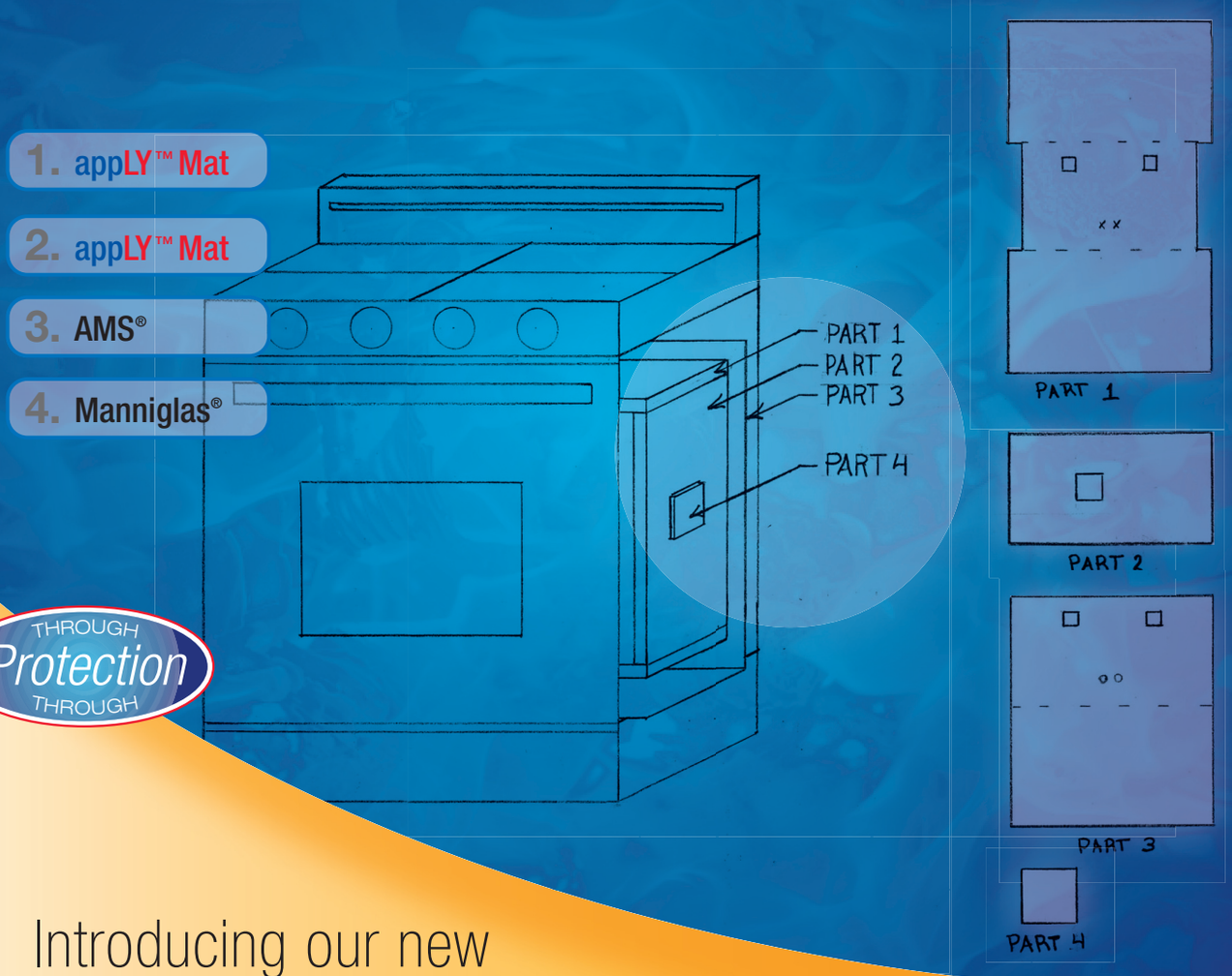
In a global market where performance standards are becoming increasingly stringent, careful selection of the appliance components like steel, porcelain, electronics, **and insulation** are critical not only to meet these performance requirements, but also to satisfy consumer demand.

Lydall has a broad offering of Engineered Insulation Materials and has supplied the appliance industry for decades. Our appliance application and technical expertise is a result of years of investment and is unparalled in the industry. We have the necessary skills to understand the source and mechanism of heat transfer as well as the impact that various materials have on the overall application.

When thermal protection is one of your top 5 performance requirements, call Lydall! John Walsh, our Global OEM Account Manager is available to assist you with your thermal or acoustical application needs. Contact him at 518-880-1078.

THERMAL PROTECTION

Is it one of your top 5 performance requirements?



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