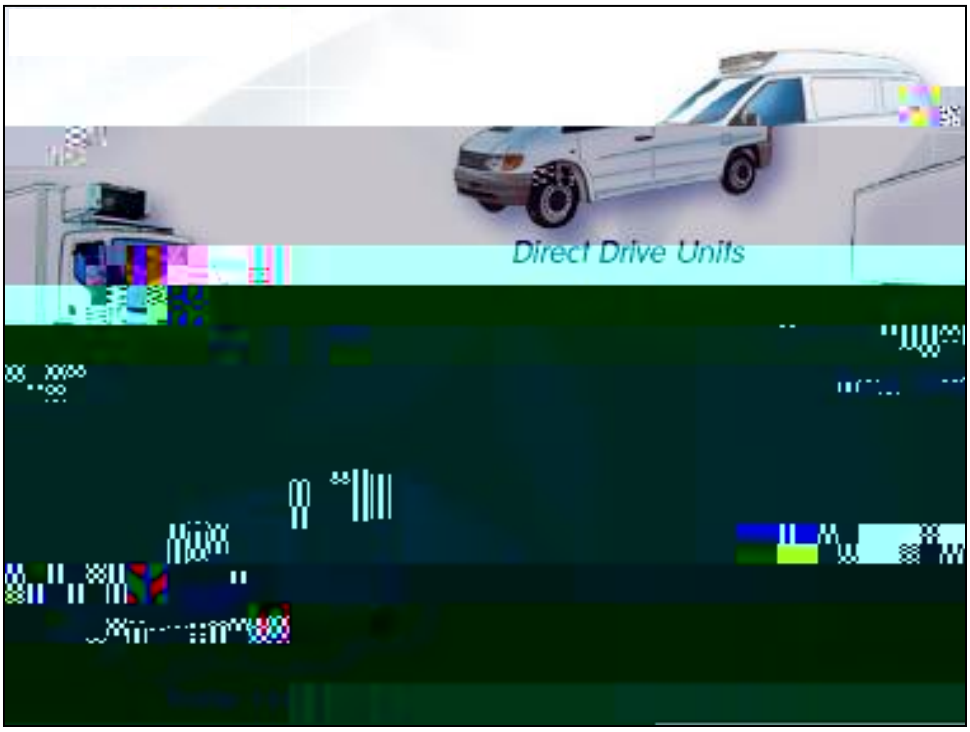
REDUCING THE ENVIRONMENTAL IMPACT OF REFRIGERATED TRANSPORT VEHICLES USING VACUUM INSULATION PANELS (VIPs)



A. Hadawey and S. A. Tassou

School of Engineering and Design
Brunel University

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Executive Summary

Effect of using VIPs on reducing the thermal load of a refrigerated vehicle was investigated for two different temperatures +2°C and -18°C for different operating conditions. The transmission load of the refrigerated vehicle considered in this report is responsible for more than 70% of the thermal load; the enhancement of the insulation with VIPs would reduce the total thermal load of the refrigerated vehicle by around third. Consequently, we can conclude that the running time of the refrigeration unit and thus its fuel consumption and its emissions would be reduced by one third with VIPs under the same working conditions.

According to the case study considered in this report, the VIPs are promising solution to reduce the cooling requirements of a refrigerated vehicle. Therefore, they can be either used to reduce the fuel consumption and emissions of a diesel refrigeration unid lett t 43 656.55 Tm[

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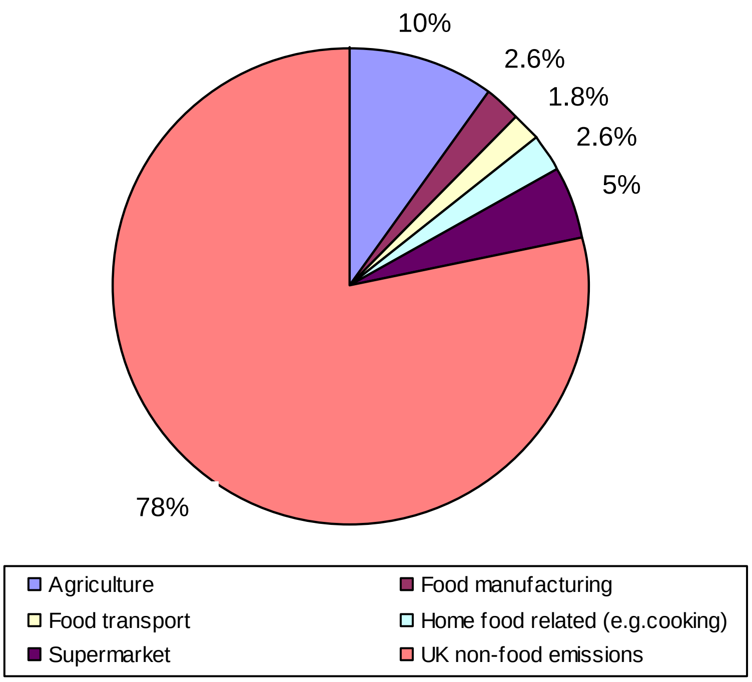
1. Introduction

The commercial food sector is responsible for 22% of the UK's total greenhouse gas emissions (this includes agriculture, food manufacturing, transport and retailing in supermarkets). Retail and distribution of food contribute approximately one third of this, mainly through the burning of non-renewable fossil fuel to provide heat and power. [1].



Contribution of food to UK's green house gas emission

The contribution of food transport to the UK's greenhouse gas emissions is estimated to be 1.8% (motive power and refrigeration whenever necessary have presumably been taken into account in this calculation).

Between 1978 and 1999, the distance food moved in the UK increased by 50% and food transport remains one of the fastest growing categories of road freight. Airfreight uses six times more energy than lorries and about eighty times more than sea vessels per kilometre during long haul. Local food is often described as coming from within a 30-mile radius of the use point [1].

In a VIP, the gaseous heat transfer is almost negligible so heat transfer is limited to solid conduction (2-3mW/ (mK) for fumed silica) and thermal radiation (1mW/ (mK) for fumed silica with an opacifier).

The core material must have a very small pore diameter, an open cell structure, a good resistance to compression (because of atmospheric pressure and be as impermeable to infrared radiation as possible [5]. The most popular core material seems to be fumed silica because it does not need such a high vacuum as other materials.

3. Load calculations for a refrigerated vehicle

We may use an example to illustrate the potential benefits or drawbacks of using VIPs to reinforce the insulation values of refrigerated vehicles. We consider a refrigerated vehicle with the following specifications: the walls, ceiling and doors comprise 2mm of aluminium alloy (external surface), 60mm of polyurethane foam insulation and 3.175mm of glass fiberboard; the floor is composed of 3mm of mild steel (external surface), 60mm of polyurethane foam and 3mm of aluminium

3.2. Solar radiation adjustment

Solar radiation increases significantly the refrigeration load of a semi-trailer. The cooling requirements of stationary vehicles have been found to increase by 20% when exposed to sunlight for several hours [3]. That is why aluminium plates and reflective paints are usually used on the exterior of refrigerated vehicles to reduce the heat gain through radiation

3.4. Infiltration by air exchange (door openings)

The heat gain from air infiltration during door openings is considerable in the case of delivery vehicles. It is, therefore, necessary to take it into account in this modeling work. A simplification of the equation developed by Gosney and Olama is given in ASHRAE [2] (applicable for fully established flows):

$$q \quad 0.577WH^{1.5}\frac{Q_S}{A}\frac{1}{R_S}$$

In the spreadsheet model, the average load related to door openings is calculated hour by hour. For example, if we consider a T-second opening, the resulting thermal load for the hour during which the opening occurs (Q_4, in kW or, since this is the average power over an hour, in kWh) will be calculated by:

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3.5. Precooling load

The precooling load of the insulated body is the heat that must be removed from the vehicle to bring its interior surfaces to the planned thermostat setting before loading it with the produce to be carried. The temperature pulldown of the warm air inside the

5.1. Long haulage operations (Case A)

The vehicle is used continuously and spends most of the time on the road, covering long distances with just a few deliveries. Therefore, both the precooling load and the infiltration during door openings are neglected.

General information	
Daily use of the vehicle	24h
Thermal load calculation	
Transmission load	Taken into account
Precooling load	Ignored
Product load	Taken into account
Door openings	Ignored
Other (thermal) loads	Ignored

6.1. Effect of ambient temperature

Case B was considered to investigate the effect of ambient temperature

7. Conclusions

- Significant reduction in the thermal load, up to 60% and consequently in the energy consumption of refrigeration units can be achieved with vacuum insulating panels, depending on the operating con19(i)-4 799f-4 77( )-349(pa)-8 achieved con1 0.0249(uni)-4frig

8. References:

[1] UKCERK. *Catering Policy* (available online,