KEEP IT COOL A GUIDE TO TRANSPORT REFRIGERATION

HUBBARD

A Zanotti Group Company

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INTRODUCTION

New legislation governing the storage and transport of chilled and frozen foods has meant a big increase in the demand for refrigerated vehicles. This demand is not only for more vehicles, but also for a greater range of types and sizes to suit a host of new applications. As a result, there are now more bodybuilders becoming involved in the preparation of refrigerated vehicles, and those traditionally involved are facing new challenges posed by unfamiliar types of vehicle.

One thing is certain. The performance of transport refrigeration is going to be monitored in the future as never before - by operators, by their customers, and by Environmental Health Departments. So it is vital that new refrigerated installations are prepared, and perform, to the high standards demanded by the regulations.

In view of these major changes, we thought it would be nice to offer our customers some general guidance on basics of vehicle refrigeration, and on the process of selecting the most appropriate refrigeration unit. So we have written this booklet to do just that. We hope that it will be interesting and helpful to anyone involved in the business, but especially those who are relatively new to this specialised area of bodybuilding.

ABOUT THIS GUIDE

This booklet is not a design manual; it is intended only as a basic guide to transport refrigeration. It will not tell you everything that you may need to know in order to design or specify a refrigerated vehicle system.

The first few sections of the guide give a basic overview of refrigeration, insulation, and vehicle operation. The section titled Calculating Refrigeration Capacity then describes in some detail how to work out the size of fridge needed. The last section on Unit Selection discusses in general terms the things other than refrigeration capacity that you need to consider when specifying a fridge unit.

As we've said, this booklet probably won't answer all your questions, so if you need any help at all with an installation, contact our sales department. We will be delighted to provide you with general or technical advice, and any level of practical assistance.

We're here to help; just call us.

WHAT IS TRANSPORT REFRIGERATION?

Okay, we realise this sounds like a pretty silly question, but it's surprising just how much misunderstanding there is on the subject. So, to avoid any confusion, we'll risk being accused of stating the obvious…

PART OF THE COLD CHAIN

Chilled and frozen products generally go through a number of storage and transport stages before reaching the final consumer. The stages along the way must form a complete 'cold chain', with products passing from one link to the next without any significant rise in temperature.

Freezer ☛ Transport ☛ Coldstore ☛ Retail

❄ ☛ ❄ ☛ ❄ ☛ ❄

Chiller ☛ Distribution ☛ Retail

Transport refrigeration is just one vital link In this cold chain. Except in very rare circumstances, its job is not to cool products down, but only to keep them from warming up during the journey.

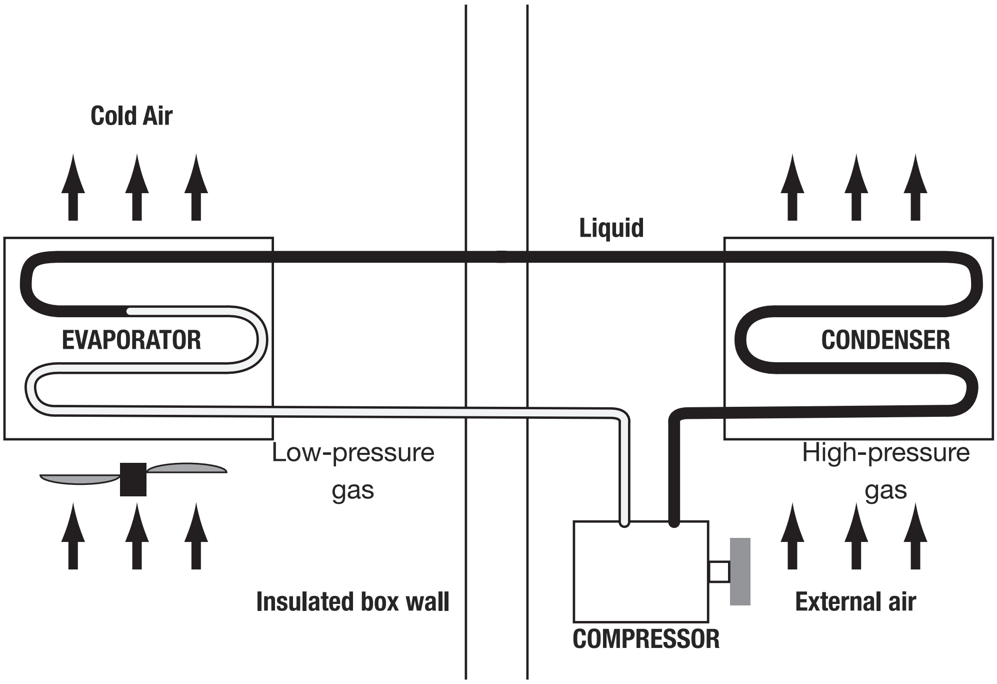
HOW DOES IT WORK?

Before we start discussing refrigerated vehicles, let's just do away with a very common misunderstanding about how refrigeration itself works - by going back to school for a minute.

Repeat after us:

- There is no such thing as 'cold'.
- Refrigeration units do not make 'cold'; they remove heat.
- The more heat you remove from something, the colder it gets.
- If a cold item is put in a warm place, it will absorb heat and start to warm up again.

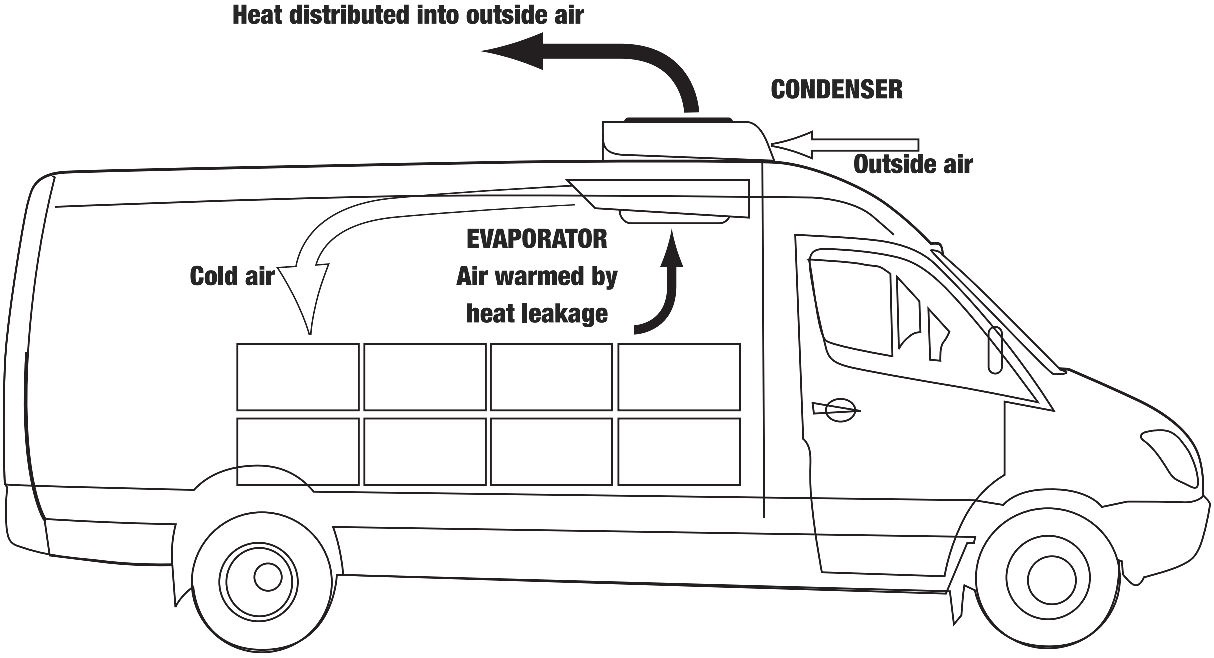
Most refrigeration systems have three main parts, and work In basically the same way.



The Evaporator	has tubes containing cold liquid refrigerant which absorbs heat from the surrounding air. In the process, the refrigerant turns from liquid into low-pressure gas. The gas is pumped away from the evaporator, taking the absorbed heat with it.
The Compressor	pumps the refrigerant into a high· pressure gas.
The Condenser	has outside air blown through it. which removes heat from the refrigerant gas and turns it back into liquid to go round the circuit again.

So, a refrigeration unit is not some sort of 'cold machine', making 'cold' and putting it in! It works by removing heat from one place and putting it somewhere else.

In the case of a refrigerated vehicle, the fridge unit simply removes heat from the inside and distributes it into the air on the outside.

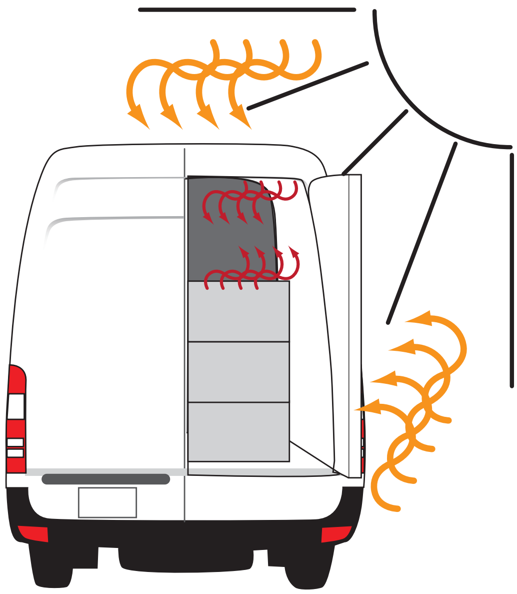


We've already said that the products should be loaded at their correct chilled or frozen temperature, so what is there for the fridge unit to do? Why is there any heat for it to remove?

This is the main question that has to be answered before a suitable fridge unit can be chosen, so we'll return to it in more detail later. Briefly, though, there are several sources of heat into a vehicle:

- some leaks in through the body and its insulation
- some gets in each time the doors are opened
- some may still be produced by the load, even after it's been cooled

and, of course, the refrigerated body Itself must be cooled down by the unit before the products are loaded.



A COMPLETE SYSTEM

From what we have just said, it's easy to see that any refrigerated vehicle must have two essential parts:

1. An insulated body	to stop as much heat as possible from outside getting to the products on the inside.
2. A fridge unit	to cool down the inside of the body, and then to remove any heat that gets in during normal operation of the vehicle.

For the vehicle to do its job as part of the cold chain properly, these two parts must work together as a complete system. This means that:

- the insulated body must be as efficient as possible at keeping heat out
- the fridge unit must have enough power to remove all the heat that can't be kept out by insulation

To put it simply:

if	HEAT LEAKING IN	is equal to or less than	HEAT TAKEN OUT	then	PRODUCT STAYS COLD
if	HEAT LEAKING IN	is greater than	HEAT TAKEN OUT	then	PRODUCT WARMS UP

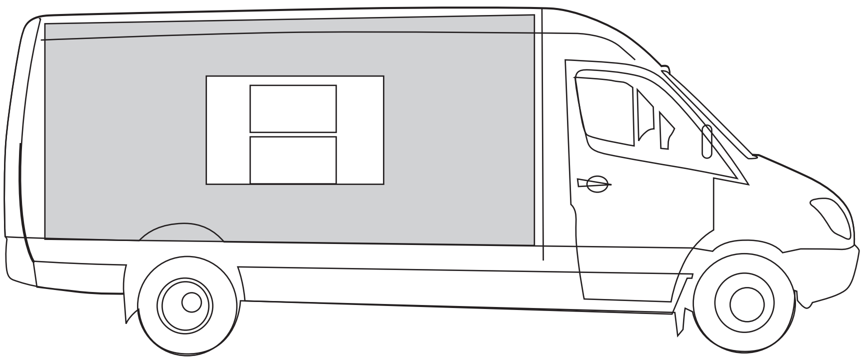
So which do you consider first when fitting out a refrigerated vehicle - the body or the fridge unit? Most definitely the body and its insulation. Until you know how much heat is likely to get into the vehicle, you cannot specify how powerful the fridge must be to remove it.

The rest of this part of the booklet gives some advice on how to reduce heat entering a vehicle, and shows how to estimate the amount that does get in. When you know this, you know how much power the fridge unit must have - and this is the most important consideration when selecting a unit.

ABOUT INSULATION

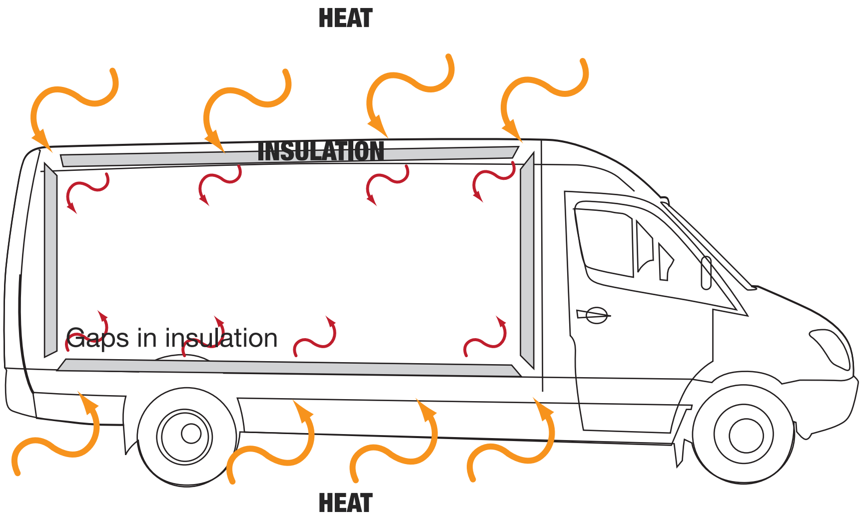
No matter how good it is, insulation cannot stop heat getting into a vehicle; it can only slow down the rate at which it gets in. As a general rule, the thicker the insulation is and the better it's fitted, the more it will slow down heat penetration.

Unfortunately, though, there is always a compromise between what would be most efficient, and what is practical.



There are two ways that heat defeats insulation: it goes through it, and it goes around it.

Both need to be combatted if the insulation is to be effective.



The first problem reducing the amount of heat that penetrates through insulation - is relatively easy; you simply use an adequate thickness of a good quality insulation. The second - reducing the effect of leaks and weak points in the insulation may be much more difficult, depending on the design of the vehicle.

The total of all the heat that penetrates the body, even after your best efforts to insulate it, is called the **Transmission Load,** and this must be estimated as accurately as possible as part of calculating the required power of the fridge unit.

The following paragraphs discuss the problems of insulation and the way they affect Transmission Load in a bit more detail.

MATERIALS

There are many, many things which definitely, absolutely, positively do not qualify as insulating materials for refrigerated vehicles!

They include: polystyrene ceiling tiles, cork wall tiles, plasterboard, loft insulation, screwed-up newspaper, and empty space. Of course, we're not for one moment suggesting that you would think of using any of these but we've come across them all at one time or another, and you can take our word for it that they don't work.

The two materials generally recommended for vehicle insulation are:

1. high-density styrofoam
2. high-density polyurethane

Both materials have good insulating properties, relatively low weight, and don't crumble to dust as a result of vehicle movement.

Most pre-fabricated insulated panelling used for building conventional refrigerated box vans and trailers uses one of these materials. The insulating material is sandwiched between outer skins to make the panels rigid and to provide the required surface finishes. The outer skins may be made from various materials, including GRP. a combination of plywood and GRP, aluminium, stainless steel, etc.

For Insulating panel vans, styrofoam and polyurethane are available in slab form which can be cut and fitted as necessary to foilow the contours of the van. Once the insulation is fitted the van is normally finished off inside with a plywood and GRP lining.

EFFECT OF THICKNESS

As anyone who's insulated a loft knows, the basic rule of insulation is, the thicker the better, but there's obviously a limit to what is sensible. As a compromise, it has now become fairly standard practice to use one or two thicknesses, according to the required internal operating temperature of the vehicle.

- For chilled operation (+4°C and above) the normal recommended thickness is 50 - 75mm
- For low-temperature operation (+4°C to -18°C) the normal recommended thickness is 100 - 125mm

Again, we must stress that these thicknesses apply only when using the correct insulating materials. The effect of having a thinner layer of insulation over the whole or any part of the body area is, quite simply, that heat will penetrate at a faster rate. If thin or uneven insulation is unavoidable, the Transmission Load will be greater, and a more powerful fridge will be needed to cope with It.

THE K FACTOR

Discussing the effectiveness of insulation In general terms is all very well up to a point. Eventually, though, you will want to calculate preny accurately the total amount of heat leaking into the vehicle, and for this you'll need some proper measure of insulation efficiency. So here it is. Il's called the **K Factor**, and it is a measure of how much heat (in Watts) passes through 1 square metre of the material for every degree Celsius difference across it. So, the K factor is expressed in Watts per square meter per degree Celcius . W/M²/°C. Good insulating materials have a low K Factor; bad ones have a high K Factor.

Fortunately, although it is nice to know what K Factor is, you don't have to measure it yourself; the manufacturers of the insulating materials specify it, and you just use the number In the calculations of the heat leakage lor the whole body as we show on page 15.

WEAK POINTS - WHAT THEY ARE AND HOW TO REDUCE THEM

We have just said that the K Factor of an insulating material tells you how efficient it is at keeping heat out. Unfortunately, this holds good only for areas of undamaged material of even thickness. Clearly, if the insulation of a body has gaps, thin bits or holes in it, heat will go through more easily.

The amount by which these weak points reduce the efficiency of the insulation is called the Body K Factor.

The more serious the weak points are, the lower the body efficiency and the more powerful the fridge you'll need to make up for it. Some bodies are better than others, but it is impossible to eliminate weak points in the insulation altogether.

BOX VANS

Traditional insulated box vans are generally the most efficient, because the whole body is made from pre-fabricated insulated panels of even thickness. There is normally only one door, and this is insulated to at least the same standard as the rest of the body. What's more, the way the door is fitted allows efficient seals to be used. On such vans, the body K factor is typically better than 0.4 to 0.7 W/M²/°C for frozen and chilled applications respectively.

PANEL VANS

Converted panel vans are a different matter. They are not designed or built with refrigeration in mind, and can cause some real problems when it comes to insulation. A badly converted one, or one with special difficulties, may have a body K factor as high as 1.5 W/M²/°C. However, converted panel vans are increasingly popular as refrigerated vehicles, and, provided the conversion is done carefully, they can be very satisfactory. The key word is 'carefully'. Taking care to insulate each part of the body as well as possible, and then using a fridge with the right power output, makes all the difference between an inefficient van and a good one.

So, where are the possible weak spots for insulation, and what can you do about them. Here are a few pointers.

BODY CONTOURS AND ACCESS POINTS

Getting around the awkward bits of a van - like wheel arches, door hinges and tight corners - without leaving weak areas in the insulation can be a something of a problem. Unfortunately, there are no easy answers; it's just a matter of dealing with each area in turn, taking as much care as possible to make the insulation continuous. Be prepared to cut extra pieces specially to fill in all the odd shapes and crevices, and seal joins in the insulation. Don't underestimate the effect of even the smallest gap. Where gaps must be left for access to shock absorber mountings, spare wheel fixings, etc., some form of removable insulation should be fitted. Otherwise, they can cause a surprising amount of heat leakage.

STANDARD DOORS

Standard panel van doors present several insulation problems:

- the open panels are normally too shallow to take the necessary thickness of slab insulation
- in many cases clearance must be left for the locking mechanisms
- the structural double-skinned areas have no access at all for inserting insulation
- door seals are not designed to prevent heat leakage, and there isn't normally the space to add anything more effective

There are a number of ways of dealing with these problems, including:

1. Insulating the existing door as well as possible, and using a higher-rated fridge to compensate for the heat leakage that still exists.
2. Extending the depth of the door inside with a moulding of GRP or similar material sufficient to take a solid slab of insulation. (If it's possible to form an additional seal between the door and body insulation, so much the better.)
3. Replacing the standard doors with slab doors.

N.B. Fitting a plastic strip curtain in each door opening helps to reduce the ingress of heat.

SPECIAL DIFFICULTIES

Some conversions for particular applications mean that you end up with areas of the body that simply cannot be insulated effectively. Sliding doors are one example where, at best, only a thin layer of insulation can be fitted, and the seals are almost bound to be poor. Even worse are roller doors, which are virtually impossible to insulate, and the seals are non-existent!

In these cases, often the only practical approach is to allow for the heat leakage when you calculate the overall body efficiency, and accept that a higher-rated fridge unit will be necessary.

SUMMARY

The points we've made here about insulation are intended only to outline:

1. What should be aimed at when preparing a vehicle
2. Where some common problems arise

so that these can be taken into account when selecting a fridge unit.

We couldn't possibly give details of how to set about insulating any particular vehicle; in any case, that's not the purpose of this booklet.
In short, the general rules for insulation are:

- Use only good-quality polyurethane- or styrofoam-based material with a known K Factor.
- Use the right thickness 50 - 75mm for chilled operation: 100 - 125mm for frozen.
- All areas, as far as possible, to the same standard - sides, roof, floor and doors.
- Take considerable care to prevent gaps or thin areas which increase the Body K Factor.
- When everything possible has been done with insulation, take care to make enough allowance for the body K factor when calculating the total heat leakage of the vehicle.

The details of how to calculate total heat leakage are given on page 15.

ABOUT OPERATION

Unfortunately, you can't insulate an open door. So every time the vehicle stops to load or unload lots of warm, moist air gets in, and the fridge has to work hard to cool it down again before it starts warming the products. The more often the doors are opened, and the longer they're open each, time, the harder the fridge must work to recover the temperature.

It is, therefore, essential to know how the vehicle will be operated before trying to select an appropriate fridge unit. A vehicle/fridge combination that's perfectly suitable for long, single-drop journeys may be totally unable to cope with a typical local delivery application.

THE SERVICE LOAD

The total of all the heat that enters the vehicle as a result of door openings is called the Service Load. To calculate it properly, you must estimate how many times per hour the doors will be opened, and for how long each time. Be pessimistic! Take the worst possible assessment of the operating pattern, and then add a safety margin. Because door openings can add a great deal of heat - especially if the operator is careless - it's best to overestimate them rather than end up with a fridge that can't handle the service load.

Where frequent door openings are unavoidable, it may be worth installing plastic strip curtains and/or weir boards inside the doors to reduce the movement of air during loading and unloading.
When the vehicle goes into service make sure the user understands very clearly that it will maintain the required Internal temperature only if the door openings are kept within the design estimates.

The details of how to estimate the Service Load as part of selecting a fridge unit are given on page 17.

ABOUT PRODUCTS

HEAT INPUT

The main thing to say about heat from products loaded into the vehicle is that you don't normally need to consider it when specifying a refrigeration unit. We've included a mention of it here only for the sake of being able to say why it shouldn't be a problem.

There are two ways that products could possibly add heat to the vehicle:

1. By not being cooled to the right temperature before loading
2. By actually producing heat after loading

The first simply should not happen. As we have said before, it is not usually the job of refrigerated transport to act as a mobile chiller or freezer. The size of the fridge unit needed to achieve significant product cooling would make it completely un-economic for all practical purposes. If something has gone wrong further up the cold chain, vehicle refrigeration is unlikely to put it right, and probably should not be expected to do so.

The second possible problem - of heat being generated by the product itself - is also a very small one. Provided they're cooled properly in the first place and not allowed to warm up again, very few products will give off enough heat to bother the vehicle refrigeration.

Mushrooms and live maggots are a couple of rare exceptions, but we prefer not to talk about these!

As a general rule, you should be able to ignore the effect of heat introduced by the product load when it comes to calculating required refrigeration capacity.

CONDENSATION

Some very moist products, like chilled meat and fish, produce high levels of condensation inside refrigerated vehicles. This can cause ice to form on parts of the system, which seriously reduces its efficiency. The answer to this problem is to use a fridge designed for frozen food temperatures (L Models), even for chilled applications. The reason for this is that all low-temperature units in the Hubbard range have defrost facilities for automatically removing any build-up of ice.

HEATING AS WELL AS COOLING

When the temperature outside is very low, some products such as cut flowers may actually need a little warming to protect them from the cold. For these special applications, there are Hubbard units that can serve as heaters or fridges, as the need arises.

CALCULATING REFRIGERATION CAPACITY

The total amount of heat entering a refrigerated vehicle is called the Total Heat Load. The ability of a fridge unit to remove heat from the vehicle is called its Capacity. For a vehicle to be capable of maintaining the required internal temperature, the fridge capacity must be at least equal to the total heat load. In the previous section, we outlined the nature of the heat sources that make up the total heat load; here we show the actual calculations necessary to estimate the amount of heat involved.

TOTAL HEAT LOAD

Just as a reminder, the sources of heat making up the total heat load are:

The Transmission Load	which is all the heat leaking in through the body insulation.
The Service Load	which is all the heat that enters when the doors are opened.
The Product Load	which is all the heat given off by the products being transported

Total Heat Load - Transmission Load + Service Load

As we explained earlier in the booklet, the effect of the Product Load should, in most cases, be small enough to be ignored altogether. So, in practice, the calculation for total heat load is just:

TRANSMISSION LOAD - WHAT YOU NEED TO KNOW

To estimate the Transmission Load for any particular body, you need to know:

- the body K factor in Watts/M^2/°C
- the mean surface area (A) of the body in M^2
- the temperature difference (TD) between the inside and outside in °C

Once these are known, they are simply multiplied together to find the transmission load - i.e:

K x A x TD - Transmission Load (TL) ....Watts

We will consider each factor in turn.

ESTIMATING BODY K FACTOR

As we've already said, the body K factor is the average heat leakage per square metre per degree celsius (W/M2fc) over the surface of the body. If there were no weak points in the insulation, body K factor would be the same as the insulation K Factor. But in the real world, there are nearly always some weak points which increase the body K factor, and so increase heat leakage.

Unfortunately, it is very difficult to give any reasonable guide figure for body K factor; it depends entirely on the construction of the particular vehicle. As a very rough guide, a well-constructed conventional insulated box van should have a body K factor of around 0.4 W/M^2/°C. At the other end of the scale, a converted panel van with, say, poorly-insulated sliding doors could have a K factor as high as 1.5 W/M^2/°C. If in doubt, conduct a heat leakage test to establish the actual figure. (If you have problems with this, our Applications Department will be pleased to help.)

CALCULATING MEAN SURFACE AREA

Mean surface area is simply a calculation of the body area which takes account of the insulation thickness, and so allows a more accurate estimate of heat leakage than using just the internal or external areas. It is calculated by first finding both the internal and external surface areas of the body, and then applying a relatively easy piece of arithmetic.

It is very important to measure body dimensions accurately for this operation. A fairly small error can make a big difference to the final calculation of area, which could easily lead to under or over specifying the refrigeration capacity.

To calculate mean surface area do the following:

1. Measure (in metres) the external body height, width and length.
   Call these H1, W1, and L1 respectively.

2. Calculate the internal body height, width and length.
   Do this by subtracting two insulation thicknesses from each of the external dimensions, and call them H2, W2 and L2 respectively.

3. Calculate the external surface area (A 1) in square· metres:

   A1 = (2 x H1 x L1) + (2 x W1 x L1) + (2 x H1 x W1) .... M^2

4. Calculate the internal surface area (A2) in square metres:

   A2 - (2 x H2 x L2) + (2 x W2 x L2) + (2 x H2 x W2) ....M^2

5. Calculate mean surface area (A) in square metres:

   A = √(A1 x A2) ....M^2

TEMPERATURE DIFFERENCE

Temperature difference is the difference between the outside (ambient) air temperature, and the required design temperature inside the refrigerated compartment. To ensure standard levels of performance, it is becoming normal practice to use the ambient and design temperatures specified by ATP regulations, even though they are not yet mandatory in the UK.
These regulations define a standard ambient temperature of +30°C, and classify refrigerated vehicles into three classes capable of maintaining specified internal temperatures:
Class A: O°C. Class B: -10°C. Class C: -20°C.
Therefore, temperature difference (TD) is the difference between +30 and the design class temperature. e.g:
For a Class C vehicle, TO = 30 - (-20) = +50.. °C

CALCULATING TRANSMISSION LOAD

Once you have found the body K factor (K), mean surface area (A), and temperature difference (TD) using the calculations just described, calculating the Transmission Load for the whole vehicle is very simple:
Transmission Load (TL) = K x A x TO ....Watts

ESTIMATING SERVICE LOAD

Service load can only be estimated, because it is based on a prediction of the operating pattern of the vehicle. It is vital to get from the end user a realistic assessment of the worst possible operating pattern, and use this in the calculations. Any under-estimate of service load could result in a system which just cannot maintain temperature.

You will need to know:

- journey time (hours)
- total number of door openings per journey
- duration of each door opening (minutes)
- the temperature difference (TO) between the inside and outside (as already determined for Transmission Load)

To estimate the Service Load, do the following:

1. Calculate the average number of door openings per hour:

   Door opening frequency (F) = openings per journey.... journey time (hours)

2. Refer to Table 1 on page 18 to find the Basic Service Load for the calculated opening frequency (F) and estimated opening duration. For example, a frequency of 4 openings per hour of 5 minutes duration each gives a basic service load of 3.47 Watts/M^3/°C.

3. Use the internal dimensions H2, W2, L2 (already used for calculating surface area) to calculate the internal volume of the vehicle:

   Internal volume (V) = H2 x W2 x L2 ....M^3

4. Finally, calculate the Service Load (SL) by multiplying the Basic Service Load (from Table 1), the Internal Volume (V) and the Temperature Difference (TO). I.e:

   Service Load (SL) K Basic Service Load x V x TO ....Watts

Table 1

BASIC SERVICE LOAD Watts/M³/°C

Door Openings Per Hour	Opening Duration (Minutes) 3	4	5	6	7	8
1	0.61	0.62	0.63	0.64	0.66	0.67
2	1.29	1.34	1.39	1.45	1.51	1.58
3	2.04	2.17	2.31	2.40	2.67	2.89
4	2.89	3.15	3.47	3.86	4.34	
5	3.86	4.34	4.96	5.79		
6	4.96	5.78	6.94			
7	6.23	7.59				
8	7.71	9.92				
9	9.46		Impractical to operate			
10	11.57		in this area			

Note that these figures are based on our experience, and are provided for guidance only.

CALCULATING TOTAL HEAT LOAD

As we have already said, Total Heat Load is simply the sum of the Transmission Load and Service Load, calculated as described above. i.e:

Total Heat Load (THL) = TL + SL ....Watts.

Provided all estimates and measurements required for the earlier calculations have been made carefully, this Total Heat Load will provide a realistic basis for selection of a suitable refrigeration unit. The unit must have a capacity at the required operating temperature which is at least as great as the calculated total heat load.

Of course, there are other requirements to satisfy when choosing a fridge, such as size, type, and physical configuration. The next section outlines some of the points to consider.

UNIT SELECTION

This section is not intended to provide a complete procedure for selecting a particular Hubbard refrigeration unit. For one thing, our range is continually expanding, so such a procedure would soon be out of date. For another, final selection of a unit requires detailed consideration of vehicle chassis type, and other factors that would simply take up too much space to go into here. Instead, we just provide some general discussion on the various aspects of selecting a unit. For more detailed Information on particular model ranges and their applications, refer to the literature available from our sales department. Alternatively, call us on 01473 892218, and we will provide all the assistance you need.

CAPACITY

As we have said a number of times, the capacity of a fridge unit - the amount of heat it can remove is the first consideration when choosing a unit. No matter how suitable it may be in other respects, if a fridge doesn't have sufficient cooling capacity, it won't do the job!

So, how do we rate capacity? Just like Total Heat Load, it's rated in Watts at different operating temperatures, If you look In most of our product brochures, you'll see a table similar to the one below setting out the unit's capacity at a range of box temperatures.

Refrigeration Performance

Ambient 30°C	Box°C	Watts
Truck drive	+5	2,975
compressor	0	2,365
1800rpm	-10	1.920
	-20	1,200
Standby	+5	2,300
	0	2,020
	-10	1,425
	-20	850

The figures represent the maximum capacity of the unit, at 1800 rpm compressor speed, when operated at each temperature. All refrigeration units become less efficient with falling temperature, which is why the capacity becomes progressively smaller, and why it is vital to specify the unit for the intended operating temperature.

In most instances, identifying a unit of the right capacity is just a matter of finding one with a rating greater than the calculated total heat load at the intended box temperature. For example, suppose the vehicle was for products to be transported at O°C, and the total heat load was calculated to be 2000 Watts. The table opposite shows this unit to have a capacity of 2635 Watts at O°C - comfortably greater than the heat load, and therefore more than adequate for the job. However, if the requirement had been for deep-frozen products, the figure of 1200 Watts at -20°C shows that this unit could not possibly cope with the 2000 Watt load.

TRAFFIC FACTOR

You may have noticed in the table above that the performance figures are given assuming a compressor speed of 1800rpm. This is because the refrigeration output of some systems which are driven directly from the engine drops as the engine slows down below about this speed.

In light traffic or open-road conditions the engine will be above this speed for most of the time, and the effect of an occasional slow-down can be ignored. In city traffic, with the engine only idling for much of the time, the fridge could spend long periods working below its rated output. As a result, it may fail to maintain the box temperature, or to recover it after load/unload stops.

Therefore, if it is known that a vehicle will be used substantially in city traffic conditions, a Traffic Factor should be added to the fridge specification. The unit selected should have a capacity **at least** 15% greater than the total heat load of the vehicle.

SYSTEM TYPE

It is quite likely that anyone of several different Hubbard units would provide the necessary output capacity, so the next stage of selection involves identifying a system which best suits the particular vehicle and application in all other respects, including efficiency, cost, ease of fitting and use, available options, etc.

Below we outline the main areas of consideration; for more detailed information on any aspect of particular models, either check the latest issues of our product literature, or contact our sales department for assistance.

CONFIGURATION

With the exception of eutectic systems, which we'll deal with in a moment, all vehicle refrigeration systems have three main working units:

the evaporator	which is the part that cools the air inside the vehicle.
the condenser	which is the part that transfers the heat to the outside air.
the compressor	which drives the refrigerant round the system

Different systems have these three units physically located in various configurations - partly for operational reasons, but mainly to suit the vehicle. The two basic configurations are as follows:

Split	where the evaporator is fitted inside the refrigerated body, and the condenser is mounted outside - usually on the cab roof or the front of a box body, but sometimes under the body. Location of the compressor will depend on the system drive type. Split systems are available for panel vans and box bodies.
One-piece	where the evaporator and condenser form a single unit, normally mounted on the front of a box body. There are two further variants of this configuration. In one, the evaporator projects into the body; in the other, the whole system is outside the body, with no intrusion at all into the load space.

In addition to these two system configurations, there are the eutectic systems which operate in a fundamentally different way, and consist essentially of just pre-cooled beams arranged in the front or roof of the body. There's more about how these work under Drive Type below.

DRIVE TYPE

One of the main differences between systems is the type of drive used for the compressor. No one type is 'best'; they each have advantages and disadvantages which make them more or less suitable for any particular application. Below is a brief outline of the various drive types.

Note:
In some applications, there may be no need for the fridge unit to run at all while the vehicle is moving. For example, where a vehicle is used only for transporting products a reasonably short distance from one cold store to another with no door openings in between, the box insulation alone may be sufficient to maintain temperature. For these applications, many Hubbard fridge units can be supplied without any vehicle-mounted drive or power source; they are powered for pre-cooling and standby only, by connecting them to an external electrical supply. See Standby, under Options below.

Low-voltage Electrical

In these units, the compressor is driven directly from the vehicle's own 12V electrical system - usually without any modification. Because the power available is limited, they are relatively low-capacity units, intended for small vans carrying chilled products. Their main advantages are that they are relatively cheap, simple to install and operate, and compact enough to fit even the smallest van.

Direct Drive

In these systems, the compressor is mounted on the vehicle engine, and directly driven by a pulley and belts from the crankshaft. They are split or one piece systems generally suitable for trucks up to about $45m^3$, and are available for chilled or frozen operation. Their advantages are that they are comparatively cheap, economical to run, and virtually silent. One disadvantage is that their output drops as the truck engine slows down, and this can cause problems in city traffic conditions.

Independent Engine Drive

As the name suggests, these units have their own built-in engine - normally a small diesel - as the power source for the compressor. This makes them completely independent of the vehicle engine, so the refrigeration operates at full efficiency regardless of traffic speed. What's more, it can continue operating while the vehicle is stationary for overnight stops, ferry crossings, and so on. The systems are generally configured as one-piece units for front-mounting on box bodies, and come in a range of capacities for chilled and frozen operation of bodies up to 8m in length.

Eutectic Systems

Eutectic Systems are fundamentally different to all other types of system, because they work completely without power while the vehicle is operating. Instead of the normal evaporator unit which needs a constant circulation of refrigerant, they have an arrangement of sealed beams or plates containing an evaporator coil and a special liquid known as a eutectic solution. The beams are 'charged' by connecting the system to an external mains power supply while the vehicle is stationary, and running the system until the eutectic solution freezes solid. While the vehicle is in operation, the beams simply absorb heat entering the body.

In technical terms, a eutectic system relies on what is known as the 'latent heat of fusion principle'. What this means is that after the beams are disconnected from the freezer power supply, they will start absorbing the heat that enters the vehicle, but will not even begin to warm up until all the energy that was required to turn the liquid into ice is replaced. As a result, they are capable of maintaining the vehicle temperature for a considerable length of time - but only if they're properly charged. It's no good plugging the system in for a couple of hours until the beams just feel pretty cold! They must be charged for long enough to freeze the eutectic solution solid, and usually this means overnight.

Eutectic systems are completely silent in operation and require no power from the vehicle. They can produce temperatures down to -30°C, and can be configured for vehicles of any size. For low-temperature applications, the beams or plates are normally mounted in the ceiling of the vehicle. For chilled operation, they can be stacked behind an insulated bulkhead, with a fan to circulate the cold air.

SYSTEM OPTIONS

Standby

Standby is a facility for powering the fridge unit from an external electrical supply. This is used to pre-cool the vehicle before loading, and to maintain the box temperature while the vehicle is stationary. Standby is available as an option on most types of system.

Heat/Cool

Some Hubbard models are capable of heating as well as cooling. This is an option which can be used to prevent frost damage to products such as cut flowers when outside air temperatures are very low.

Auto Defrost

Low-temperature versions of Hubbard units are provided with an automatic defrost system, which operates at timed intervals to prevent excessive icing of system components.

Vehicle Fitting

The design of Hubbard condenser and evaporator units allows them to be fitted easily to most panel or box vans, according to the fridge model. The various types of engine-mounted drive units are supplied complete with fitting kits, which are available for a very wide range of vehicle types. Before making a final selection of a unit, please contact our sales department to check the availability of a fitting kit for the particular fridge model and vehicle type.

Service

Hubbard customers can take advantage of fixed price maintenance schemes in mainland Britain, ensuring that their fridges are kept in optimum condition at a firm quoted price. Please ring the Service Hotline FREEPHONE 0800 0180460 for more information.

Extended Warranty

Some Hubbard models are being offered with the option of extended warranty. Ring the Sales Hotline 01473-892218 for details.

www.hubbard.co.uk

Email:transport@hubbard.co.uk

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