Purchasing efficient refrigeration – the value for money option
PURCHASING EFFICIENT REFRIGERATION
– THE VALUE FOR MONEY OPTION

This Guide is No. 278 in the Good Practice Guide Series. The Guide covers commercial and industrial refrigeration systems, and will help you to identify your refrigeration needs and to select the right contractor/consultant to implement your plans.

This Guide is aimed at purchasers of refrigeration systems, and at those procuring plant, where it will help you to achieve the installation of an energy efficient system.

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from the Energy Efficiency Best Practice Programme

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FOREWORD

This Guide is part of a series produced by the Government under the Energy Efficiency Best Practice Programme. The aim of the programme is to advance and spread good practice in energy efficiency by providing independent, authoritative advice and information on good energy efficiency practices. Best Practice is a collaborative programme targeted towards energy users and decision makers in industry, the commercial and public sectors, and building sectors including housing. It comprises four inter-related elements identified by colour-coded strips for easy reference:

— Energy Consumption Guides: (blue) energy consumption data to enable users to establish their relative energy efficiency performance;

— Good Practice Guides: (red) and Case Studies: (mustard) independent information on proven energy-saving measures and techniques and what they are achieving;

— New Practice projects: (light green) independent monitoring of new energy efficiency measures which do not yet enjoy a wide market;

— Future Practice R&D support: (purple) help to develop tomorrow’s energy efficiency good practice measures.

If you would like any further information on this document, or on the Energy Efficiency Best Practice Programme, please contact the Environment and Energy Helpline on 0800 585794. Alternatively, you may contact your local service deliverer – see contact details below.

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REASONS TO READ THIS GUIDE

Refrigeration is a neglected service to most users – out of sight and out of mind – but it will leave you out of pocket if you don’t give it the attention it deserves. It pays to manage the design and installation of refrigeration plant. By doing so, your company will benefit from:

- higher profits through lower energy costs;
- better productivity through increased plant reliability;
- reduced service call-outs and costs;
- improved quality control;
- lower environmental impact.

This Guide sets out simple steps you can follow to ensure successful procurement of efficient and reliable refrigeration plant.
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INTRODUCTION

Who is this Guide for?

This Guide is aimed at potential buyers of bespoke refrigeration systems, whether it be completely new plant or an extension to existing plant. Bespoke refrigeration systems include:

- refrigerated rooms (including cold and chill stores, beer cellars, and temperature-controlled laboratories);
- liquid chillers;
- process cooling (food or chemicals);
- central plant systems in large supermarkets.

If you are expecting to buy a plug-in type appliance, such as a stand-alone refrigerated display cabinet or a simple freezer store, refer to Good Practice Guide 277.

Throughout this Guide :

- A lightbulb is used to highlight ideas which will help you to get the most from this Guide – and the most from your refrigeration purchase.
- A triangle is used to highlight information that is very important to energy efficiency.
- A signpost is used to show you where you can find more detailed information about a topic elsewhere in this Guide, or in another publication.
- The story of Joe, a fictional character, shows how the approach suggested in this Guide can be applied in practice.
How you will benefit from reading this Guide

This Guide will show you how to:

1. work effectively with contractors and consultants to obtain efficient and reliable refrigeration systems;
2. use capital effectively to reduce running costs;
3. reduce the environmental impact of your plant.

There are at least four compelling reasons to take the design, installation and commissioning of your refrigeration plant seriously.

1. It can **cut your electricity bills**, in some cases by half. Refrigeration systems can account for a huge proportion of site electricity costs – up to 90% in some cases – so the financial rewards resulting from careful purchasing can be impressive, and they will continue year after year.

2. It can **reduce capital cost**. Taking a logical and careful approach to purchasing can reduce the cost, as illustrated in Good Practice Case Study 248.

3. It results in **better reliability** and, therefore, higher productivity. Firstly, this arises because of the care taken in the design and commissioning process. Secondly, there is a strong link between reliability and efficiency. An efficient plant runs at optimum operating conditions, which results in less wear and tear and, therefore, greater reliability.

4. It **reduces environmental impact**. Refrigeration plant contributes to global warming indirectly through the energy it consumes, since power stations emit carbon dioxide when they generate electricity. Efficient plant uses less electricity and so has lower indirect impact. In addition, many refrigerants are powerful greenhouse gases which contribute directly to global warming if they leak. Certain refrigerants also damage the ozone layer. Good design and installation will minimise leakage.

It pays to get it right first time

Refrigeration plant will work after a fashion in all sorts of adverse conditions. It will provide cooling, but perhaps not enough to meet peak conditions, or it will deliver cooling inefficiently. There are countless examples where production is slowed, quality compromised and profit eroded because refrigeration isn’t delivering the cooling it should.

The importance of long-term costs

During its lifetime, the operating costs of a refrigeration plant will be several times its purchase price. Care at the time of purchase, and perhaps a little extra investment, will pay for itself many times over.

Indeed, you will reap real dividends by taking account of operating costs when making purchasing decisions. Throughout this Guide, the main influences on running costs are reviewed, and guidance is given on how to get your contractor to give them adequate weight when preparing the design.

To compare different designs, and take due account of operating costs, it is a good idea to consider the lifetime costs of the plant you are about to buy. The feature box *How to calculate the lifetime cost* on page 18 shows how this can be calculated at the appropriate point in the purchasing process.
In many work-related fields it seems that there is never enough time to do it right, but always enough time to do it again! This is a poor way of working. It is far cheaper to get your refrigeration project right at the outset than to modify the plant once it has been installed.

It is helpful at the design stage if you can make provision for expansion and/or change of use. For example, you can arrange the pipework so it is easy to extend, ensure your plant is positioned so that the next unit fits logically in line, and leave space for more condensers or, at least, envisage where the space might be.

Further help is available

As you read, you may feel you wish to know more about refrigeration technology, or how design changes can improve plant efficiency. Appendix A introduces some of the basics of refrigeration and the box feature The top priorities for energy efficiency on page 9 gives some pointers for achieving cost-effective plant.

There is also a wide range of information available through the Energy Efficiency Best Practice Programme. This Guide is part of a suite (see the overview diagram at the front of this Guide), two of which are particularly relevant here:

- Good Practice Guide 280 Energy efficient refrigeration technology – the fundamentals describes the basic technology and equipment for refrigeration.
- Good Practice Guide 283 Designing energy efficient refrigeration plant, written for designers, explains the effects of different design decisions.

If you already own and operate a refrigeration system, Good Practice Guide 279 Running refrigeration plant efficiently – a cost-saving guide for owners will also be useful.
Can’t afford to invest in efficient plant? – You can’t afford not to!

Energy efficiency can be introduced cost-effectively into new plant, and the savings potential is excellent as a case study of frozen food distributor Doble Quality Foods illustrates. The company bought a new refrigeration system for £30,000. The additional cost of energy saving features was £4,000, but the savings achieved were £5,280 a year, giving a payback of just nine months. Energy saving features of this plant – a single, integrated system – include low power evaporator fans, large evaporators, a large condenser, efficient compressors, and comprehensive performance monitoring.

Don’t stint on your investment

Faced with a similar situation with its larger plant, Ind Coope Burton Brewery (now part of Bass Brewers) took similar care with its new installation and now saves £160,000 per year, 30% of its earlier costs. The project was completed within the original budget.
If your cooling needs are more complex than plug-in-type appliances, begin by asking whether you need refrigeration at all. Some products can be cooled using air or water without refrigeration (free cooling) for at least part of the cooling process, or for part of the year. There is no point designing an efficient refrigeration plant if it is not required in the first place – an obvious point, but one that is too often missed.

If you conclude that you do need a refrigeration plant, you must gather information to take to your contractor or consultant at a later stage. You can do this by taking the four steps described overleaf. Each step is illustrated by Joe, a fictional character working for a fictional company, Ice Breaker Ltd, with a medium-sized refrigeration demand.

HOW JOE KEPT HIS COOL – PART 1

Newly appointed operations manager Joe had been given an important responsibility – to manage the upgrading of the refrigeration plant for his company, Ice Breaker Ltd, as the existing refrigeration plant had come to the end of its useful life. Joe’s job was to ensure that the replacement project ran smoothly and economically.

Joe was determined to justify the MD’s faith in him. He knew little about refrigeration, and therefore decided to spend a few hours learning exactly what was required, and how to go about installing energy efficient plant.

Joe’s factory employed two forms of refrigeration:

- a series of cooled rooms to process his company’s products which required chilled water at 7°C;
- a freezer store that had to be kept at a temperature of –25°C.

Replacing the entire cooled room refrigeration system – pipework, pumps, motors, and so on – would be prohibitively expensive so Joe decided to interfere with them as little as possible. He concluded, however, that he needed a new plant to serve the system.

Joe knew the freezer store could not be served by chilled water because it could not produce water at –25°C, so he decided to install a new refrigeration system dedicated to this duty.
Step 1: List your cooling loads

Assess your cooling loads by asking yourself what you want to cool. Be specific – think about your entire process and its cooling implications, and quantify it by answering the following questions.

- What product do I want to cool?
- How much of this product (sides of beef, tonnes of prawns, or whatever) do I want to cool, and what size will it be?
- At what temperature will the product go into the refrigeration store or process?
- At what temperature do I want it to emerge?
- How long can I allow for it to be cooled or frozen?
- Does the freezing/cooling time have any implication on product quality?
- What are the variations in throughput (for example seasonal variations)?
- Where am I locating my refrigeration plant?

Put the answers to one side to give to a contractor or consultant later.

If you have cooling loads at different temperatures it is always more energy efficient to have separate systems for each temperature. For advice on this read the guidance in the remainder of this section and then talk to your contractor or consultant.

Step 2: Assess parasitic loads

Parasitic loads are loads on the refrigeration system other than the product or room space you are trying to cool. The most common parasitic loads are:

- fans and pumps;
- lighting;
- contributions from defrost and drain heaters;
- under-floor heaters;
- occupancy;
- air changes;
- pallets (often soaking wet);
- heat gains through insulation;
- machinery inside cooled rooms.

HOW JOE KEPT HIS COOL – PART 2

Joe looked at the cooling loads for his cooled room chilled water system and wrote down the design rating (kW output) of all the cooling coils. Beside this he wrote the operating hours for each of the rooms.

He did not know how to calculate the cooling demand of his freezer store so he decided to postpone any judgement on this until he was ready to talk to a consultant or contractor. He started a list of questions to ask a consultant/contractor later.
Make a list of the parasitic loads and, at the same time, consider ways you might reduce them (see the box below for some suggestions).

**Parasitic loads and how to reduce them**

All electrical devices that add to the cooling load cost you money twice! First you pay for the power to operate the equipment, then again through running the refrigeration system to remove the heat they produce.

**Fans and pumps.** Circulating air, chilled water and anti-freeze fluids require energy to provide the movement. 90 – 100% of the energy fed to the motors constitutes a parasitic load on the refrigeration system. Minimise these costs by specifying efficient fans and pumps, and using controls to ensure they run only when necessary.

**Variable speed drives (VSDs).** These reduce parasitic loads where the system requires pumping of a fluid like chilled water or anti-freeze solution. Good Practice Case Study 89 shows how Manchester Airport installed VSDs on pumps ranging in size from 7.5 to 37 kW, and achieved paybacks as short as one year – and VSDs cost even less now!

**Lighting.** Although nearly all storage areas need some form of lighting for both working and safety reasons, all of the electricity supplied to the lights contributes to the cooling load. To minimise running costs, specify efficient lamps and make sure that they are switched off when not required.

**Occupancy.** Whenever a person or a piece of equipment (for example, a forklift truck) enters a cold store, the refrigeration system has to remove the extra load created by their presence. For this reason, keep occupancy to a minimum.

**Air changes.** Few refrigerated spaces are sealed for extended periods. Each time warm ambient air enters the refrigerated space it will add to the load on the system. Entrances should, therefore, have well fitting, insulated doors which are kept closed whenever possible. Fit barriers, such as PVC strips or air curtains, to limit the ingress of air when doors are open.

**Heat gains through insulation.** No insulation material maintains its original characteristics indefinitely. Have it checked periodically by a specialist (perhaps with a thermal imager) to ensure that deterioration is not causing an unacceptable loss of efficiency. Include both cold pipework and walls. Ensure that vapour seals are of the highest quality and unbroken.

**Auxiliary loads.** Don’t place equipment that produces heat (for example, a refrigerator or an ice maker) in a refrigerated space like a cold store or a beer cellar. Cooling loads like this will require the refrigeration plant to run longer than is necessary, thereby consuming additional energy. Hot water pipes and drains which run through refrigerated spaces must be adequately insulated.

By combining the results of steps 1 and 2, a contractor or consultant will be able to calculate the size of your cooling demand and, therefore, the size of the plant required.

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**HOW JOE KEPT HIS COOL – PART 3**

Joe considered all the parasitic loads on the freezer store and suspected that air changes would be the largest of these. He made a note to ask the contractor or consultant for ways to improve door management/control at a later stage. He also made a list of other parasitic loads he found and potential ways to reduce them.
Step 3: Think about how the plant might be arranged

Although your consultant or contractor will give you appropriate advice, it is sensible to understand the important issues surrounding plant configuration.

- **How many systems should you have?** Energy consumption, and therefore running costs, depends on the ‘temperature lift’ the plant has to provide (which is governed by the difference between ambient temperature and the temperature of your product – see the box on page 10 for a fuller description). A higher lift means higher cost. Thus, if you have cooling requirements at several different temperatures, it can make sense to install separate systems to meet each demand.

- **Do you want to keep all your refrigeration plant in one plant room, or is it preferable to place plant close to the demand?** Many of the factors that affect the answer to this question will be specific to your site’s requirements, but the main considerations are:
  - plant is easier to operate and monitor if it is all in one place;
  - long runs of refrigerant pipework (e.g. between the refrigeration plant and the cooling demand, or between the plant and external condensers) are undesirable because they are vulnerable to refrigerant loss by leakage or damage, the refrigerant tends to pick up unnecessary heat, and pipework pressure drops reduce efficiency;
  - effective control is easier to achieve if the plant is close to what you are trying to cool.

- **Should you buy a single, large unit or several smaller ones?** The option you choose can have a big impact on both capital and running costs.

  Refrigeration systems generally work less efficiently at part load. It might, therefore, make sense for you to buy, say, three machines, each sized at a third of your maximum capacity, rather than a single machine. For most of the time, one or two of the systems can be switched off. Any stand-by requirements you have would then mean buying a fourth small machine rather than a large one.

  If you have short peaks in your refrigeration load, it can make sense to have an efficient base-load plant supplemented by a cheap ‘peak-lopping’ plant. The latter does not necessarily have to be very efficient, as it is not going to be used much. So, instead of buying two units that are moderately efficient, invest in one efficient one and use that for all the base load.

- **Could you use absorption cooling?** This technology is cost-effective and less damaging to the environment if:
  - you have a combined heat and power (CHP) unit and cannot use all of the available heat, or if you are considering a new CHP plant;
  - waste heat is available;
  - a low-cost source of fuel, such as landfill gas, is available;
  - your boiler efficiency is low due to a poor load factor.

Make a note to discuss these issues with your consultant or contractor later.
Step 4: Evaluate how you will reject heat

The heat you have removed with your refrigeration system is usually expelled to atmosphere through a water-cooled system (a water-cooled condenser and a cooling tower or evaporative condenser) or an air-cooled heat exchanger.

For plants with a cooling demand above about 50 kW, water-cooled heat rejection is the most efficient, and often the cheapest. Bear in mind, however, that:

- For plant with a cooling demand up to 50 kW, air-cooled heat rejection normally costs less to buy.
- Water-cooled systems must be protected from legionella contamination and thus have associated water treatment costs. The cooling tower or evaporative condenser must also be registered with the local authority.

What is legionella?

Legionnaires’ Disease is a severe form of pneumonia produced by a bacterium called legionella pneumophila. This can be found in many places but particularly in cooling towers, which have been implicated in a number of outbreaks in the UK although, with better management, there have been few recently. The bacterium got its name from an incident in 1976 when 29 people died after becoming ill at an American Legion convention in Philadelphia. Prevention of Legionnaire’s Disease is well understood and achieved by good management of the cooling tower, including a comprehensive water treatment regime. Evaporative condensers seem to be much less likely to suffer legionella infections.

Hold the information you have gathered in steps 1 to 4 ready to give to your contractor or consultant.
Larger condensers make real savings

Exel Logistics needed to replace the CFC refrigeration plant in its temperature-controlled storage facility in Melton Mowbray.

During refurbishment it selected larger condensers than would normally be specified, to improve energy efficiency. This has cut energy costs, because of the lower refrigeration condensing temperatures, and reduced environmental impact, because CFCs have been replaced. The two condensers were simple to install and commission, and subsequent operations have been trouble-free.

Although each condenser cost £2,500 more than a conventional unit, the additional cost was paid back in two years. The company has saved over 10% of its annual compressor energy costs, worth £2,340.

The top priorities for energy efficiency

There are many ways to improve the efficiency of refrigeration plant; however, three fundamental factors deserve the most attention as they can cut your running costs with little or no extra investment.

Cut cooling loads

The cooling load on the refrigeration system determines the size of the refrigeration plant and its power consumption. The smaller the load, the lower the power consumption. The cooling load is usually made up of a number of different components and you may be able to reduce or eliminate one or more of these. This is much easier to do at the design stage than later on when the plant is running.

Reduce temperature lift

The temperature lift is the difference between the evaporating temperature (where the cold is delivered, say at –23°C) and the condensing temperature (where the heat is dispersed from the condenser, say at 35°C). The higher the lift, the more energy it takes. The temperature lift reduces if the condensing temperature is lowered and/or the evaporating temperature is raised. The impact is fairly dramatic: a 1°C decrease in temperature lift will decrease running costs by 2 to 4%.

Minimise refrigerant leakage

Leakage of refrigerant has serious implications for your running costs – and also for the environment. Most refrigerants are expensive to replace, and many are also powerful greenhouse gases which can damage the ozone layer. An often overlooked impact on the user is that leakage reduces the plant’s cooling capacity, such that it has to run for longer to achieve the same cooling effect, costing you more. A 15% leak can halve the capacity – which doubles the running cost! Reduced capacity plant will have difficulty coping with peaks in demand.
Investment for capital expenditure normally requires authorisation by the company Board or the bank manager, and so you will need to get or make an early estimate of what the project should cost – a “budget price” (before you get formal tenders). There are two important steps to justifying the expenditure:

- getting a realistic budget price;
- presenting a good case for the investment.

### 2.1 Getting a realistic budget price

The first step is to establish a reasonable budget price. Unless you have experience of costing refrigeration plant, now is the time to seek expert advice. If you already know suitable contractors or consultants, get help from them, otherwise refer to the box *How to find the right consultant and/or contractor* on page 12.

The following hints should be helpful.

- If you are not using a consultant, limit the number of contractors you speak to (two to four is probably sensible at this stage). This avoids time wasting, and gives you the opportunity to start to build a relationship with the contractor that will benefit the project later. Invite each contractor separately to visit you at your site.

- Brief each contractor as fully as possible with all the information you gathered in Section 1 of this Guide. In doing so, they should gain a reasonable understanding of your refrigeration plant requirements.

- Give each contractor adequate time to produce a budget price. Three weeks should be enough.

- Insist on a written budget price from each contractor, together with an explanation of their understanding of the scope of the work involved, the equipment they would install and the power consumption at maximum load.

- If there is a large disparity between the budget prices, ask each contractor to justify their estimates and decide which to take based on their answers. If the disparity is small, take the higher estimate and add 15% as a contingency.

Don’t set a low budget and later cut costs to meet it. Remember, the cheapest deal isn’t necessarily the best deal as you also need to take running, and maintenance, costs into account; you can still get an economic payback period. There is a range of Good Practice Case Studies that prove this time and again. See the Refrigeration Publications List for details of the other publications available from the Energy Efficiency Best Practice Programme – call the Environment and Energy Helpline on 0800 585794 for your copy.

Don’t be tempted to set a low budget and then cut corners to meet it – the cost will be higher than you realise!
How Joe Kept His Cool – Part 5

Joe decided now was the time to talk to a contractor to get approximate costs together. He discussed the situation with his existing maintenance contractor and concluded that it did not have the resources to complete the project adequately. Joe therefore called a few friends in other companies who gave him names of possible contractors. He invited four of these to visit his site, briefed them on his needs and gave them the information he had already collected.

Two of the contractors – Blue Ltd and Red Ltd – particularly impressed him with the quality of their questions and general approach. As a result, he asked them to produce budget prices that he could discuss with his Board.

Two weeks later Joe received quotes from the two contractors. One was 50% higher than the other. An astonished Joe asked them to break down their pricing.

Blue Ltd, the contractor that had quoted the higher price, had listened carefully to all that Joe had said, and agreed with him about the use of packaged water chillers for his cooled rooms. It had taken the information Joe had about his freezer store, interpreted it and carefully chosen a plant to suit the needs he had described.

Red Ltd had quoted a smaller plant to serve the freezer store and Joe suspected that it had not taken all of his requirements into account.

To be safe at this stage, Joe decided to take Blue Ltd’s higher quote, add 15% as a contingency and use this as his budget price. He then wrote a report to the Board, presenting his case for the investment.

How to find the right consultant and/or contractor

Some users will engage a consultant on projects that cost over a certain amount, typically £25,000, otherwise it makes sense to employ a contractor.

A consultant can be defined as an individual or company that can specify or design a refrigeration system, but is independent of the process of purchasing and installing the plant. A contractor is a company that can design and install a refrigeration system.

Personal recommendation is the best way to find a consultant or contractor. Failing that, the Institute of Refrigeration (IoR) and British Refrigeration Association (BRA) both have lists of suitably qualified consultants and contractors. Other sources include the RAC (Refrigeration and Air Conditioning) Magazine Yearbook.

There is a series of questions you should ask potential contractors and consultants. The way your consultant or contractor answers – and justifies their answers – will give you valuable clues to their competence and awareness of the relevant issues.

- What sort of plants have they been involved with previously? Look for plants that seem similar to your requirements and ask for contacts as references.

- What refrigerants will the contractors suggest for your application, and why? If they can give clear reasons for their choice, their reasoning will probably be correct. Be suspicious if they say something like ‘That’s what I always use’.

- Have they read Good Practice Guide 283 Designing energy efficient refrigeration plant? A negative answer is not necessarily bad in itself. The question will enable you to demonstrate an interest in energy efficiency and, from their answer, you may be able to tell how importantly efficiency rates in their thinking.
2.2 Making the investment case

If you need to justify the expenditure to the Board or bank manager, apply four cardinal rules:

- keep the proposal simple;
- avoid technical jargon;
- concentrate on the financial benefits that will result rather than the technology;
- point out that an efficient plant is also more reliable.

There are three ways your proposal could be evaluated in financial terms:

- **payback period** – where net annual savings are estimated and a cumulative total obtained and compared with the initial investment;
- **return on investment** – where the average annual profit over the life of the project is expressed as a percentage of the initial investment;
- **discounted cash flow** – which reflects the fact that money received in the future will be worth less than it is today.

Making the case for investment is covered comprehensively in Good Practice Guide 236 *Refrigeration efficiency investment: putting together a persuasive case.*
Doble Foods invested in electronic expansion valves on direct expansion evaporators in its cold store in St Agnes, Cornwall. The valves allowed condensing temperatures to be reduced dramatically, leading to savings of around £2,750 a year and a payback of 1.4 years.

The cost of not replacing

‘Of course we look at payback when replacing old equipment. But we also look at the cost of NOT replacing it.’

Bass Leisure Retail’s Category Manager Andy Hall (pictured right) is responsible for justifying how proposed changes to its refrigeration equipment will benefit the company.

He explains: ‘Not only do we have to look at the environmental and efficiency arguments in favour of replacing kit, but also what sort of payback we can expect. Also, we need to explain not only how much the plant will cost, but also the cost of not replacing it.

Increased efficiency is critical. As well as the cost of breakdown, and the cost of lost custom, we also need to explain how much extra the old plant will cost us to run over the course of a year. And we need to emphasise how much the new plant will save us in terms of reduced energy costs.’

Bass Leisure Retail will not rest on its laurels once it has installed cost-effective refrigeration plant. Instead, the company is determined to improve further: ‘We want a supplier who is proactive in working with us to reduce lifetime costs. We don’t just want to put a stake in the ground and say this is what it is going to cost us. We have set a target of reduction in lifetime costs of a minimum of 15% to be delivered over the next three years.’
HOW TO ORGANISE THE PROJECT

All projects are organised in three stages:

- tendering;
- design and installation;
- commissioning.

At each of these stages, the purchaser and contractor have a different working relationship. For example, at the tender stage the contractor is asking you to employ them, and at the installation stage you are asking them to finish the work.

However your contract is organised, it is important to develop a good working relationship with your contractor right from the outset.

There are several approaches you can take to organising the project. It is advisable to decide which approach you’re taking early in the project and reflect the decision in your specification. The options are discussed below.

Depending on how confident you feel with refrigeration and your contractor, you may need the help of a consultant at any stage in the project. A good consultant can be your right arm as they will be able to apply their knowledge of refrigeration technology to the project and reduce your workload.

3.1 Tendering

Many refrigeration contracts are organised through a ‘single contractor partnership’. Here a contractor works with you to produce a specification, develop the design and install the plant for you. This has a number of disadvantages that can mean that you may not get the best value for money, some of which are listed below.

- The project will only be as good as the contractor – it is vitally important to find a good one!
- You lose flexibility and the competitive element when you come to specifying the hardware because the contractor will probably have preferred suppliers.
- You will be subject to the contractor’s own biases and prejudices.
- The contractor may be tempted to think short-term and, therefore, provide a poor solution, because they want to get onto the next job.

A common alternative is ‘competitive tender’. This involves asking several – typically three – contractors to tender for the work against a specification. This has the advantages of introducing a competitive element to the pricing process, and the application of several brains to finding the best way of meeting your cooling needs.
There are, however, disadvantages here, too. Truly competitive tendering requires a good specification (see the box What to include in your specification on pages 20 – 22), and the contractors’ expertise may be needed to help you complete the specification. A way around this, having worked through the steps described in Section 1, is to set down as much as you can in a specification, and invite the tenderer to help you clarify any outstanding questions. Take care with the specification and record any agreements you reach with the tenderer.

When considering competitive tender, remember that the contractors will often expect that they are being judged only on price, with little appreciation of the quality of the plant they offer. Make sure they understand the emphasis you are placing on efficiency – asking them to calculate running costs is essential, but be sure to provide the necessary information for them to do this.

Avoid splitting responsibilities between different contractors unnecessarily. This leads to complications and potential contractual disputes.

### 3.2 Design and installation

Whichever tendering route you use, you need to decide how the installation phase will be organised so that the contractor understands the scope of work you are expecting. Refrigeration systems involve most engineering trades and the interfaces between the trades are rarely simple. Thus, handling interfaces between contractors without a specialist understanding is difficult and a ‘turn-key contract’ can be a useful way of harnessing the contractor’s skills to the greatest benefit.

**A turn-key contract**

A turn-key contract involves setting the performance expected from the plant, specifying the terminal points (where the project starts and stops) and leaving all the details in-between to the contractor. The terminal points are usually quite broad, giving the contractor responsibility for organising electrical supplies and other services to the plant. This has the dual advantages of clarifying your, and the contractor’s, contractual responsibilities and minimising your own work input.

If you decide to limit the contractor to supplying the refrigeration equipment and plan to source support services separately, take care that the various sections communicate their requirements clearly to one another at the design stage. Also, be aware that you will become involved in co-ordinating activities during the installation phase.

As much as possible, avoid making alterations to the specification or plant layout during the installation phase. Any variations to the contract could be a way for the contractor to boost their profits.

### 3.3 Commissioning

Commissioning is discussed more fully in Section 5 and must be the contractor’s responsibility. It is important that the commissioning stage is carried out properly. Your relationship with the contractor will have changed again at this stage – you will be totally reliant on them to carry out the commissioning correctly. To maximise the probability of a successful outcome:

- ensure that adequate time is allowed in the programme to complete commissioning properly;
- obtain written procedures for commissioning well in advance;
- make sure that these procedures are followed;
- check the results as well as you can;
- be aware that if you use the plant before it is fully commissioned and handed over to you, you will lose some of your contractual rights.
SPECIFICATION AND TENDERING

Having decided how you intend to organise the project, you need to prepare a specification and obtain a firm price for it.

4.1 Specification

Many specifications for refrigeration equipment are poor. A survey by the Heating and Ventilating Contractors’ Association concluded that, in nearly 40% of cases, insufficient information is provided by clients for a proper tender to be prepared. This is estimated to cost around £93 million each year in terms of rework.

In one recent case, an inadequately prepared specification from a client to extend a refrigeration system resulted in tenders that varied between £60,000 and £180,000 for the same task!

Your entire refrigeration project risks failure unless you provide adequate information on which the contractors can base their bids, so include as much detail as you can about your requirements.

Sometimes it helps when comparing tenders if your specification includes a form for the tenderer to complete, highlighting the information you are most interested in. In this way, you will know that all the information has been provided, and it is easier to make comparisons.

A word of warning about safety margins

Don’t be tempted to add a large safety margin to your cooling demand at the specification stage. Specify the normal condition and any allowance for an ‘upset condition’ you want the contractor to bear in mind.

4.2 Obtaining contract prices

If you have chosen to use a single contractor, develop the specification together so that you both understand what is expected. Even then, insist that the contractor submits a formal tender.

If you are using competitive tender, ask the contractors how long they need to prepare a bid before you send out the specification. This will prevent them being forced to throw the design together quickly without adequate thought.

Encourage competing contractors to visit the site and see the location. For developments that are still at the planning stage, provide as much information as possible in the form of data and drawings for inspection.
4.3 Choosing the best tender

If you haven’t employed a consultant to choose the best tender for you, follow three simple steps.

- Check the tenders match the specification.
- Decide on the best tender based on lifetime costs (see below).
- Follow up the references you received earlier. If you have time, visit the reference sites and talk to the people who have to work with the refrigeration plant.

Before you sign on the dotted line, make sure you have selected the best system with the lowest lifetime cost at a price that is fair to both you and the contractor.

How to calculate a simple lifetime energy cost

The cost of running refrigeration plant over its life can be up to ten times the cost of the initial plant investment. It therefore pays to select the most efficient option rather than that which has the cheapest base cost. There are three steps to calculating a simple lifetime energy cost.

**STEP 1**

The main factors to take into account when assessing energy running costs are:

- **Ambient temperature variation** through the year. The ambient temperature is below 10°C for at least half the year. How does the system perform at low ambient temperatures?
- **Heat load** at each ambient temperature.
- **Compressor capacity, power input and coefficient of performance (COP)** for each ambient temperature. Compressor capacity and COP rise as the ambient goes down, so assess this carefully to calculate power drawn to meet the load.
- **Amount of time the compressor will run** as an annual percentage.

continued...
Aim for the best system with the lowest lifetime cost at a price that is fair to both you and the contractor.

Some contractors may tell you the TEWI (Total Equivalent Warming Impact) of the plant they are proposing to supply. This is a measure of the environmental acceptability of a piece of refrigeration equipment in terms of its total impact upon global warming. It is calculated by a formal method standardised for the industry. TEWI combines both the direct impact on the global warming of emissions of refrigerants to atmosphere and the indirect effect resulting from the consumption of electricity, which involves the release of carbon dioxide at the power station. It is useful for comparing the environmental effects of different design concepts.

**STEP 2**

You can now calculate the **power input** during the year. Your compressor or equipment supplier can help you with this calculation. For each ambient temperature:

\[
\text{Power input} = \text{number of hours per year that cooling is required} \times \text{power input (kW)} \times \text{percentage running time of the compressor during cooling requirement}
\]

Add the answer for each ambient temperature to reach a grand total for the year. Don’t forget this is just the compressor power – the condenser and evaporator fans and any other big electrical loads must be added to this.

**STEP 3**

Multiply the power input by the number of years expected from the plant and check your electricity bills to estimate the cost per kWh. This will give you a fair idea of the lifetime energy cost of your plant.

For a more comprehensive calculation method, see Good Practice Guide 283 Designing energy efficient refrigeration plant.

HOW JOE KEPT HIS COOL – PART 7

When he received the tenders, Joe found that the capital costs for the project showed Red Ltd as the cheapest and White Ltd as the most expensive. Although capital costs figured large in his mind, Joe also considered the running costs. This now made Red Ltd the most expensive, with Blue Ltd and White Ltd very close together. Both calculated that the running costs for the new plant would be 20% lower than for the old.

Joe had been impressed by the approach of both Blue Ltd and White Ltd, and by the references given by other clients.

Based on this and on lifetime costs he chose Blue Ltd as the contractor.
WHAT TO INCLUDE IN YOUR SPECIFICATION

Scope of work
Set out what you want your consultant or contractor to cover. For example, are they going to build or upgrade the entire plant, or are they simply providing cooling for equipment you have already specified? This will affect the ‘duty specification’ and the ‘terminal points’ referred to below.

If provision for future expansion is required, discuss with the consultant or contractor the best way to provide this. It rarely makes sense to invest much money in this sort of provision, but thinking about how it might be achieved costs little and can save difficulties later.

Refrigerant
Specify that the refrigerant chosen should not be a CFC or an HCFC, or contain either of these.

Duty specification
Include a clear definition of what you are trying to cool. If you do not have all the information listed below, discuss this with your consultant or contractor who should be able to guide you.

If you need your contractor or consultant to work out your cooling demand, give them as much information about the cooling loads as possible.

For cooling a room space they will need to know:
- the dimensions of the room;
- the temperature to which you want to cool the room;
- what will be going on in the room (storage or work);
- if it is a cold store, details of the product being stored;
- the number of people who will be working in the room;
- the temperature of items entering the room;
- approximately how often the door will open and closed;
- details of the humidity requirements (if this is important to your process or storage requirements);
- details of the construction of the room – how thick the walls are and what they are made of (or, if they are supplying it, all the information they will need to design it).

For cooling of solids, they will need to know the design details of the cooling plant, or if they are supplying this:
- what the product is;
- the processing weight (units/hour or weight/hour);
- the starting temperature;
- the final temperature you require;
- any special requirements such as humidity in the cooling area, permissible weight loss, etc.

If you are cooling a liquid, you need to specify at least two of the following:
- liquid flow rate;
- inlet and outlet temperature and duty in kW or Btu/h (maximum and minimum);
- details of the liquid if it is not water.

See Appendix B for more guidance on refrigerants.

continued...
WHAT TO INCLUDE IN YOUR SPECIFICATION (continued)

If you propose to use water or an anti-freeze solution to distribute cooling, you could ask the consultant or contractor to design the whole system, in which case they will need to know all the details listed opposite for the final consumers of the cooling. If they are simply providing a service to consumers that is already specified or already exists, specify it in just the same way as described for cooling a liquid.

Heat rejection

Discuss how heat will be rejected (i.e. the condenser type) with your contractor or consultant and then include it in the specification.

Other items to specify

Terminal points (where the consultant’s responsibility for services like electricity and water start and stop) for:

- the refrigeration system itself (in whatever form you are buying it);
- the condenser or heat rejection water system;
- electrical supplies;
- civils (building) work, bases and steelwork.

State who is responsible for making the connection at terminal points.

Location

A map of where the plant is situated (regionally and within the site).

Instrumentation

Even for the smallest plants, insist on pressure gauges at the inlet (suction) and outlet (discharge) of the compressor. They only cost a few pounds and will be essential for monitoring the plant later.

It is useful to be able to monitor the amount of energy that your plant consumes. For the smallest units an hours-run timer will give you a good indication and costs very little. Plants over about 20 kW motor rating justify an electricity (kWh) meter. They are much easier to install at this stage and are invaluable for monitoring performance later. Larger plants will justify more instrumentation for later monitoring.

Standards and legal/regulatory requirements

Ensure that your contractor/supplier complies with, and enables you to comply with, all legal and ‘good practice’ requirements including:

- British Standard BS4434 Specification for safety and environmental aspects in the design, construction and installation of refrigerating appliances and systems (or EN 378, which will supersede it when published);
- other relevant British or internationally-recognised standards;
- CE marking;
- the Institute of Refrigeration (IoR) Codes of Practice for the appropriate refrigerants;
- the IoR publication Minimisation of refrigerant emissions from refrigerating systems;
- the Pressure Systems and Transportable Gas Containers Regulations;
- the Control of Substances Hazardous to Health (COSHH) Regulations;
- other Health and Safety regulations and legislation (ask the supplier for any appropriate data sheets);

Monitoring requirements are discussed in Good Practice Guide 279, Running refrigeration plant efficiently – a cost-saving guide for owners.
WHAT TO INCLUDE IN YOUR SPECIFICATION (continued)

- waste disposal regulations;
- CDM (Construction (Design and Management)) regulations 1994 (if you are not familiar with these, your consultant or contractor is required to advise you of your responsibilities, and those of others);
- Good Practice Guide 283 Designing energy efficient refrigeration plant (a companion Guide to this – encourage your contractor to read it).

Training and documentation

Ensure your consultant or contractor provides training where necessary. The level of training will vary depending upon how much work you intend your own staff to carry out. The minimum staff work will be routine daily and weekly monitoring checks which can be demonstrated during commissioning and detailed in the manuals provided. Greater staff involvement will require more extensive training.

Ensure that your consultant or contractor provides comprehensive manuals to accompany the plant. These should include data collected during commissioning, and all of the design data for the plant. Two copies of all documentation should be supplied.

The Pressure Systems Regulations apply to all refrigeration systems with a compressor drive motor over 25 kW (see Section 6.2). Among other requirements, is a regular inspection by a ‘Competent Person’ according to a ‘Written Scheme for Examination’. It is sensible to ask your consultant or contractor to provide this for endorsement by your ‘Competent Person’, as defined in the Regulations.

Performance testing

Bearing in mind performance testing, decide the level of testing you require. This can have a significant impact on installation costs.

Information required from your consultant or contractor

**Estimated running costs**

Ask the contractor/supplier to estimate the annual running costs for the plant. Good Practice Guide 283 Designing energy efficient refrigeration plant provides a standard method for making this estimate. To do the calculation, they will need to know:

- how the plant will operate – the pattern of availability of heat or requirement for cooling, depending on the basis you wish to use to control the unit;
- the cost of electricity.

This information needs to be accurate if you wish to compare different bids, or plants designed for low energy consumption with others. No model of future performance will ever be perfect, so try to give as good a picture as possible without too much complication.

**Other items**

Specify the level of maintenance support you require for the plant. Get the costs of maintenance for at least the first year quoted separately in the bid.

Get the tenderers to include a priced list of recommended spare parts appropriate for you – it can save costly delays later if you buy these at the outset.

If appropriate, they should indicate any hazardous area classification that may apply.

For welded steel pipe systems, they must confirm that the welder has appropriate qualifications, and set out an agreed non-destructive testing regime.

Request written procedures for leak and strength testing of the system upon completion.
The need to determine capital and lifetime running costs

‘Variance in running costs can completely wipe out any variance in capital cost in tenders.’

So says Bass Leisure Retail’s Category Manager Andy Hall, following its experience with refrigeration replacement. Having decided to refurbish its refrigeration equipment, Bass Leisure Retail identified three potential UK suppliers.

In an attempt to understand the real costs and efficiencies of its equipment, Bass decided to talk directly to the manufacturers rather than their agents or distributors. Mr Hall found that trying to compare equipment was not straightforward: ‘There is no European standard for the efficiency of our cooling equipment, and there are no standard conditions for testing. They each had their own way of proving their figures. On top of this, they each offered different accessories and switches, and so on. We don’t have the internal expertise to judge the equipment without direct comparisons.’

The company therefore decided to discover for itself the real cost of ownership of its equipment over an assumed 10-year life.

Mr Hall explains: ‘The elements that we wanted to measure were capital purchase cost; installation costs (based on time of installation at the standard rate); servicing costs; predicted spares costs; and energy costs to cool a standard Bass cellar. These are the five measures that we added together.

You can get people to bid for the capital cost – that’s easy. The spares costs likewise. It’s the other three that are less easily measurable. The servicing cost, the installation cost and the energy cost need to be measured – you can’t just quote for them. We asked all three companies to commit to a testing programme managed by a consultant. To prevent us incurring extra costs, and to ensure the manufacturers’ commitment, we asked them to pay for the testing.’

The consultant identified a location for the test, set up the testing protocol, wrote a specification for the testing, and sent it to the three manufacturers.

They committed to it after making some minor changes. They then supplied equipment that met the full specification for testing. The tests resulted in clear measurements of the energy costs, installation costs and servicing.

According to Mr Hall: ‘It really provided an opportunity for the most technically competent and committed supplier to win. By providing this framework one particular company, which was both the most committed and the most technically capable, won. They weren’t the cheapest for equipment but they provided the lowest lifetime costs.’
Once you have awarded the contract, the contractor should detail their design, order equipment and plan the installation. Get written procedures for commissioning as early as possible.

5.1 Installation

Installing the refrigeration equipment requires the same project management skills as any other installation job and, as such, need not be described fully in this Guide. However, a few special items deserve attention.

- Any dirt that gets inside pipework and equipment can cause excessive wear, blockage or fouling of heat exchangers and other problems later. Insist that the contractor caps all open pipe ends to prevent dirt entering, and fits strainers at strategic points and cleans them regularly during the first few days of operation.
- Check that the equipment delivered is installed according to the drawings. Items like the slope of refrigerant lines, method of support and the orientation of pipework reducers can seriously affect performance.
- Allow adequate time for concrete to cure inside a cold store.

Ask if your contractor is familiar with Good Practice Guide 281 Installation and commissioning for efficient refrigeration plant – a guide for technicians and contractors. Reading it may also help you to understand the issues better.

5.2 Commissioning

Once installed, the plant must be commissioned. Commissioning involves checking that the equipment is installed correctly, ensuring controls are properly set and training in-house personnel in the plant’s operation. If the plant is poorly commissioned it will run inefficiently. Ensure that:

- adequate time is allowed in the programme to complete commissioning properly;
- the contractor follows the written procedures for commissioning you received from them at the installation stage.
Insist that the contractor carries out a thorough leak and strength test, and that the system is suitably evacuated and dehydrated before final charging. At the very least, insist that they check the:

- system’s operating pressures and temperatures;
- storage/produce temperature, including thermostat settings;
- electrical supply and operating parameters of the compressors and all other electrical motors;
- function of any special features built into the compressor(s), including off loading or capacity control devices, etc;
- oil level in the compressor(s);
- settings and operation of any pressure safety devices;
- setting of all system controls, including the superheat of the thermostatic expansion valve(s);
- operation of the defrost system, where one has been used;
- level of vibration.

On top of this, make sure the contractor:

- trains your in-house technicians in how to spot potential problems so that they can alert you before they become serious;
- commissions as closely as possible to conditions of maximum load in the summer months;
- records the operating conditions for you (it is also a good idea for you to check them) so that you can refer back to them later.

**HOW JOE KEPT HIS COOL – PART 9**

In late summer, potential disaster struck Joe’s project. It was delayed because a rush job meant the production department was unable to release the plant to Joe on schedule. The contractor, Blue Ltd, was able to cope with this delay, but it meant that the commissioning started later than planned.

Blue Ltd took responsibility for commissioning the plant, but Joe kept a close watch to check that it followed the procedures agreed at the specification stage. At important points, Joe formally witnessed demonstrations of parts of the plant in operation.

As each system was commissioned, Blue Ltd’s staff explained to Joe’s maintenance technicians how the plant worked so that, once the plant was fully operational, they would be able to identify problems that occurred at an early stage and arrange for them to be fixed.

Blue Ltd also provided manuals and commissioning data two weeks after it had completed the commissioning process. As agreed, it also provided a written scheme of examination to cover Joe’s responsibilities under the Pressure Systems regulations.
5.3 Performance testing

After commissioning, insist that the contractor conducts one or more performance tests to ensure that the plant is meeting its design specifications. There are four main tests.

1. A demonstration run. This involves operating the plant under supervision for a reasonable period and noting the performance data from the normal instrumentation. The results can then be compared with the specification and the contractor’s tender. Clearly, this is best carried out at times when the plant is operating at close to design capacity.

2. A formal full-load test. Here, special arrangements are made to ensure that the plant operates at its design conditions. This may involve simulating cooling loads with electric heaters, and additional calibrated instrumentation. It is rarely worth conducting a formal full-load test because of the expense.

3. A factory test. Where the refrigeration equipment is a factory-built, packaged unit, most suppliers will be able to offer a factory test at a much lower cost than a site test. Clearly, this is not applicable to site-assembled systems.

4. Monitoring over an extended period. Here, the plant is monitored over a period and its performance checked against predicted running costs. However small your plant is, it is always worth monitoring. The least that you should do is log suction/discharge gauge pressures. If they change when they shouldn’t, you will know something is wrong and you can alert your contractor.

Longer-term monitoring of your plant is worthwhile in terms of reliability and energy efficiency – it helps you spot things going wrong before they become serious.

See the companion Good Practice Guide 279 Running refrigeration plant efficiently – a cost-saving guide for owners for more on monitoring

HOW JOE KEPT HIS COOL – PART 10

Joe and Blue Ltd had expected to complete commissioning during August, so they had intended to test the equipment fully during the warm weather. The delay meant that it was not ready for testing until September and the weather was rapidly turning colder. At the tender stage, Joe had arranged to retain 5% of the contract value for three months so that, following successful performance tests, he could be assured that the plant was working reliably.

Joe and Blue Ltd discussed this situation and agreed that, in lieu of a formal performance test, they would monitor the operation of the plant together and Blue Ltd would demonstrate how the observed performance would vary in warmer weather.

Joe realised he was vulnerable here, so he decided to employ a consultant to analyse the performance results.

The consultant studied the monitoring readings that Joe and the contractor were proposing to take, and suggested some additional information that was available and could be useful.

At the end of three months, the consultant examined the performance figures and was able to advise Joe that the plant could be expected to meet its design warm weather performance and the 5% retention could be released.
Following commissioning and performance testing, the contractor should give you at least two complete sets of the plant’s operating documentation (which you should have requested at the specification stage – see the box *What to include in your specification on pages 20 – 22*). This will enable you to ensure that future servicing maintains the installation at its optimum efficiency.

The documentation should include:

- the design operating parameters;
- a complete set of installation drawings, together with system piping and wiring diagrams;
- the operating and servicing instructions for any major items of equipment included in the installation;
- quality assurance documentation on pressure vessels, installation and testing;
- a list of recommended spare parts for critical equipment, with prices;
- a complete set of control settings;
- the records from the commissioning procedure;
- a maintenance plan.

*Developing a good working relationship with your contractor pays dividends – probably no one else knows your plant as well as them*
Keep one set of operation documents in a safe place and the other on site, making it available to service technicians on request.

### 6.1 On-going management, maintenance, and care

Don’t fall into the trap of sitting back and letting the annual service take care of ensuring efficiency – the chances are that it will not be adequate to protect your profits.

Continue to work with your contractor to maintain your plant’s efficiency and reliability. Encourage the contractor to look for ways to improve performance by pointing out anything you are doing wrong as an end user.

Now, read Good Practice Guide 279 *Running refrigeration plant efficiently – a cost-saving guide for owners* to get the most out of your plant.

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**Continuous improvement pays dividends**

An ice cream manufacturer initiated an energy reduction programme for its refrigeration plant, with the main target of lowering the plant’s condensing temperature. The company implemented various changes including redesigned pipework runs, better gas purging and dispensing with condensing pressure control. This progressively lowered the head pressure from around 11 bar to 8 bar, which translated into energy savings worth around £150,000/year.

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### 6.2 The ‘Pressure Systems Regulations’

Be aware that the Pressure Systems and Transportable Gas Containers Regulations place responsibilities on the ‘users’ of refrigeration systems. If your compressor drive motor is over 25 kW, it is advisable to consult the Health and Safety Commission guidance note on the subject, HS(R)30.

The draft European ‘Pressure Equipment Directive’ will replace these Regulations in due course.
SOME BASICS ABOUT REFRIGERATION SYSTEMS

Refrigeration exists to cool a product or maintain it at a lower temperature than its surroundings. A refrigeration system uses a refrigerant to transfer heat from the fluid or product being cooled to ambient air or water.

A simple refrigeration system comprises the following:

- **An evaporator** in which the refrigerant boils (or evaporates) at a temperature lower than the product being cooled. The evaporating refrigerant absorbs heat from the product as it boils, thus cooling the product.

- **A compressor** which compresses the gas generated in the evaporator.

- **A condenser** in which the high pressure gas pumped by the compressor is liquefied (or condensed). During this process the refrigerant rejects heat, usually to ambient air or water.

- **An expansion device** which drops the pressure of the condensed liquid back down to the pressure of the evaporator.

It will also employ a set of controls that might include the following:

- **A thermostat.** This switches the refrigeration system off when the required temperature has been reached and switches the system on again when the product has reached its upper temperature limit. The differential between off and on must not be so low as to cycle the refrigeration compressor on and off rapidly.

- **Pressure switches for system protection.** Here a high-pressure cut-out switch turns the compressor off when the pressure on the high pressure side of the system rises too much. A low-pressure cut-out shuts off the compressor if the suction pressure drops below a set limit (for example, due to loss of refrigerant from the system).

- **Compressor motor protection devices.** These switch off or reduce the load on the compressor if the electrical current rises too high.
The amount of heat a refrigeration system removes, ‘the extraction rate’, can be measured in watts. The extraction rate will depend on the size of the system and the conditions under which it is operating.

To drive the system, energy (usually in the form of electrical power) has to be put into the compressor’s motor and to other motors for pumps, fans, etc; this is also measured in watts. The system is operating at optimum efficiency when the minimum input power achieves the maximum heat extraction. The expression used to describe the efficiency of a refrigeration system is ‘coefficient of system performance’ (COSP).

\[
\text{COSP} = \frac{\text{Refrigeration capacity (watts)}}{\text{Total system power input (watts)}}
\]

Don’t confuse COSP with the commonly quoted COP (coefficient of performance) which relates to the power consumed by the compressor alone.
REFRIGERANTS AND THEIR ENVIRONMENTAL EFFECTS

There are two environmental issues directly related to refrigerants: ozone depletion and global warming.

Ozone depletion
The types of refrigerant that were most popular from the 1940s until recently – CFCs and HCFCs – have been shown to cause damage to the ozone layer high in the atmosphere. This has undesirable effects that include an increase in the incidence of skin cancer. When the seriousness of this became apparent, it was agreed internationally (through the Montreal Protocol) that CFCs and HCFCs should be phased out of use.

Global warming
Refrigeration plant contributes to global warming indirectly due to the energy it consumes, since power stations emit carbon dioxide when they generate electricity. Efficient plant uses less electricity and so has a lower indirect impact. In addition, many refrigerants are powerful greenhouse gases which contribute directly to global warming if they leak.

Regulations on CFCs and HCFCs
As a result of ozone depletion, in the EU:

- production and importation of CFCs were banned in 1995;
- HCFCs are being phased out of production by 2015.

At the time of writing, more regulations are planned to forbid the use of CFCs by January 2001. The same regulations will accelerate the phase-out of production and use of HCFCs in the EU (their use will be forbidden in most new plants from January 2001, and for maintenance of any plant from 2010).

Replacements for CFCs and HCFCs
The agreements in the Montreal Protocol have led to the development of a range of refrigerants to replace both CFCs and HCFCs. Some are direct replacements that can be ‘dropped in’ to most existing installations. Others are only suitable for new, or severely modified, plant. Some of these contain HCFCs and will, therefore, be phased out along with HCFCs themselves – the most common of these are listed in the panel on the right.

Ask your consultant or contractor about the best refrigerant for your needs. In view of the phasing out of HCFCs and blends that contain them, it is recommended that no new plant should be installed which uses any of these types of refrigerant. You can check the list of refrigerants in the box to ensure that the refrigerant offered by your contractor does not contain HCFCs.

APPENDIX B

The most common CFCs:
- R11
- R12
- R13B1
- R502

The most common HCFCs:
- R22
- R123

Refrigerants that contain HCFCs:
- R401A, B and C
- R402A and B
- R403A and B
- R405A
- R406A
- R408A
- R409A and B
- R411A and B
- R412A
- R414A and B
- R509A
Many of the replacements for CFCs and HCFCs are also greenhouse gases, i.e. they contribute to global warming through the greenhouse effect if they escape to the atmosphere. The exceptions are ammonia and hydrocarbons, such as propane or iso-butane.

**Control of leakage**

Whatever refrigerant is chosen, it makes both financial and environmental sense to avoid the opportunity for leaks to occur. Leakage costs you a great deal more than just the lost refrigerant. It reduces efficiency (can double running costs), reduces capacity (peak loads may not be met), reduces reliability and is technically illegal once you know it is happening.

Many factors affecting leakage from refrigeration plants relate to the construction of the equipment itself. You, as the buyer, can help minimise the possibility of leaks occurring by specifying that:

- the refrigerant charge is to be kept to a practical minimum;
- long runs of refrigerant pipework are to be avoided where possible (locate the equipment close to the cooling demand and condenser, or consider a heat transfer fluid such as water or an anti-freeze solution to transfer the cooling);
- contractor’s staff who will handle refrigerants must be registered by ACRIB (Air Conditioning and Refrigeration Industry Board) as qualified refrigerant handlers (they will have a special card to say so).
SOURCES OF FURTHER INFORMATION

The following are a list of useful addresses and publications for the Refrigeration and Air Conditioning industry.

**British Refrigeration Association (BRA)**
Henley Road, Medmenham, Marlow, Buckinghamshire SL7 2ER
Tel: 01491 578674 Fax: 01491 575024
Internet Home Page: http://www.feta.co.uk

The BRA has sections for designers, users, manufacturers, distributors and installers of components and systems in the refrigeration industry. It also has an active interest in training. The BRA publishes single page Fact Finder sheets dealing with topical issues in the industry and recommended procedures concerning specific factors in the design and operation of refrigeration systems and companies. It also publishes *Guideline methods of calculating TEWI*.

**The Heating and Ventilating Contractors’ Association (HVCA)**
ESCA House, 34 Palace Court, Bayswater, London W2 4JG
Tel: 020 7229 2488 Fax: 020 7727 9268

**Building Services Research and Information Association (BSRIA)**
Old Bracknell Lane West, Bracknell, Berkshire RG12 7AH
Tel: 01344 426511 Fax: 01344 487575
Internet Home Page: http://www.bsria.co.uk

**Department of Trade and Industry**
1 Victoria Street, London SW1H 0ET
Tel: 020 7215 5000 Fax: 020 7222 2629
Internet Home Page: http://www.dti.gov.uk

*Environmental Division*, 151 Buckingham Palace Road, London SW1W 9SS
Tel: 020 7215 1018

The DTI publishes a number of booklets on the environmental aspects concerning the refrigeration and air conditioning industry. It has also commissioned and published market studies into the use of refrigerants within the industry.

**Environment and Energy Helpline**
Tel: 0800 585 794

This is a free advisory service on environmental and energy efficiency issues provided, for UK businesses, by the Government. It is also able to advise on the range of free information available via the Government’s Energy Efficiency Best Practice Programme and Environmental Technology Best Practice Programme.

Internet Home Page: http://www.energy-efficiency.gov.uk

**The Institute of Refrigeration (IoR)**
Kelvin House, 76 Mill Lane, Carshalton, Surrey SM5 2JR
Tel: 020 8647 7033 Fax: 020 8773 0165
Email: instor@ibm.net
Internet Home Page: http://www.ior.org.uk

The IoR is the professional body of the refrigeration industry. It provides information to the industry through published papers, seminars, Codes of Practice etc.
ACRIB is the umbrella trade organisation for the refrigeration and air conditioning sector.

**TRADE JOURNALS**

There are a number of publications dealing with the refrigeration and air conditioning industry.

**Refrigeration and Air Conditioning (RAC)**
Published by:
EMAP Business Communications, 19th Floor, Leon House, 233 High Street, Croydon CR0 9XT
Tel: 020 8277 5412  Fax: 020 8277 5434
Email: AndrewB@Trenton.emap.co.uk (for the editor)

**AC&R News**
Published by:
Faversham House Group, 232a Addington Road, South Croydon, Surrey CR2 8LE
Tel: 020 8651 7100  Fax: 020 8651 7117
Email: paul@fav-house.com (for the editor)

**ACR Today**
Published by:
Battlepress Ltd, Nithsdale House, 159 Cambridge Street, Aylesbury, Buckinghamshire HP20 1BQ
Tel: 01296 425151  Fax: 01296 435091
Email: info@aydee.com