

## 50 years of Container Refrigeration

*Dr. Dermott Crombie reviews some of the developments in Container Refrigeration over the past 50 years. Dr Crombie is Vice President of Thermo King's Global Marine Solutions division, offering reefers and marine gensets to the world's largest shipping lines. An engineer by background, he earned his Ph.D. on research into alternative refrigerants.*

Less than 70 years ago, people in the developed world ate fresh food, available in season, and grown within 150 km of where they lived. Beyond that, they ate dried or canned foods. The advent of transport refrigeration opened up a whole new era. Today, people in the developed world eat fresh produce all year round.

Thermo King Corporation is this year celebrating its 50th anniversary in the container shipping industry. The company built the first container refrigeration unit in 1956, just 18 years after the company invented the first truck refrigeration unit – and an industry that changed the world. Not only did Thermo King Founders Joseph Numero and Frederick Jones' landmark invention usher in the era of frozen foods, large supermarkets and the restaurant industry, they also opened up endless possibilities for fresh and frozen produce transport throughout the world.

The introduction of refrigerated container traffic in 1956 meant the beginning of easy availability of any type of perishable produce from anywhere in the world, any time, allowing us to buy avocados, kiwis, or passion fruit any month of the year.

In the intervening years, the technology has been further refined. Today's largest container vessels carry 10,000+ TEU, with ever-larger ships planned. These vessels carry as many as 1500 reefer plugs, and together reefer containers carry over half the world's perishables (the remainder travelling either in bulk reefer vessels or by air).

### **Technology progress**

The quality of the cargo, and its subsequent shelf life, delivered by today's reefer containers, is amazing. Very fine temperature control, humidity control, atmosphere control, all combine to provide produce delivered to the supermarket shelf that is almost as fresh as the moment it was harvested. Many cargoes travel for 4-6 weeks, and the technology available today ensures temperatures deviating as little as 0.2degC from set-point throughout the voyage. The ability to raise, or lower, humidity, coupled with the ability to reduce the oxygen levels, and raise CO<sub>2</sub> mean the product respiration can be slowed, effectively putting the cargo to sleep for the voyage. The fact that the cargo is carried in a self-contained container means this environment exists from the packinghouse to the final warehouse.

All reefer containers operate per an ISO standard, meaning the equipment has to work on voltages anywhere from 360V to 500V and from 48.75Hz to 61.5Hz. Unfortunately, even this wide range of power is not adhered to everywhere in the world and still equipment is expected to operate and perform which is quite a task, however several manufacturers have mastered it.

Next comes the external environment. A voyage from the southern hemisphere to the northern hemisphere means moving a cargo from winter to summer, or vice versa. So the equipment may be cooling the cargo for part of the voyage, and heating it for part of the voyage. Further, the ambient crossing the equator may easily exceed 45degC. Within these changing temperatures, the reefer unit is expected to keep the cargo at its precise temperature throughout.

Next, a respiring load may require ventilation from the outside air. External air may be very humid, or very dry, and it is important that this ventilation does not adversely affect the humidity in the cargo space.

Finally, the temperature of this air will also vary enormously, and several patents are employed to ensure this warmer (or colder) air ventilates the cargo correctly, but does not adversely affect its temperature.

When all of these performance criteria have been met, with varying success, the equipment has to be extremely reliable. The reliability might be easier if the equipment didn't sit on the deck of a ship for much of its life: but it has to face as harsh an environment as nature can throw at it. Yet these machines are remarkably reliable.

### **50 years of change**

In 50 years of development, many things have happened - some of which are almost distant memories.

The Ozone Hole was found in 1987, leading to the phase-out of CFCs. This meant moving from R12 and R502 to R134a and R404A for the refrigeration units, and similar technology changes in the insulating foam in the units and the boxes. By the early 1990's, this had begun in earnest. The insulated boxes on which these units fit were initially made in North America, and in Europe. Over several steps, these have migrated to Asia, such that over 90percent of all box production is today in China. This has led the reefer unit manufacturers to migrate closer to the box production, and today all the reefer units are built in Asia.

Environmental - and economic - pressures continue, with the high cost of fuel coupled with the Kyoto Protocol putting pressure on users to reduce energy usage. Today's reefers are far more efficient than anything previously available. Indeed, the latest technology uses less than 50percent of similar size equipment of just a few years ago. As oil prices continue to spiral upwards, the daily energy consumption bill is now of the same order of size as the daily lease rate on a reefer box! So equipment choice, and age, becomes significant issues.

Marine reefer units began life with reciprocating technology. This was the mainstay of the industry until the early 1990's, when scroll compressors first appeared. This industry is remarkably conservative, and it has taken several years for scrolls to become mainstream. Today, the entire industry has moved to scroll, realizing the benefits of lower weight, and improved energy efficiency.

Over the years, cargo temperatures have dropped, as new science has shown the benefits of Omega 3 fish oils, and the superior preservative effects of lower temperature on certain high-fat fish and shellfish. Studies by the Danish Fisheries Institute speak of "Fresh Fish from the Freezer"; such is the improved quality of storing fish at lower temperature. Today, reefer equipment is available to carry cargoes as low as  $-35\text{degC}$  in regular containers (and lower, down to  $-65\text{degC}$  in special cases), to yield these benefits.

### **Further improvements**

As mentioned earlier, atmosphere has an important effect on respiring cargoes. Several research institutes, in the USA (UC Davis), Netherlands (ATO), UK, and elsewhere, have conducted enormous research into post-harvest physiology. As a result, the optimal conditions for storage and carriage of many plants are now well understood. The effects of timing within the harvest period (early or late), different plant varieties, soil types, and a myriad other variables can now be factored in with some degree of certainty to predict a good outturn.

The pressure for change is not over. Further environmental pressures, and commercial pressures, will lead to the continued evolution of the reefer container. Lower life-cycle cost, lower weight, better performance, smaller environmental footprint: all these factors will conspire to ensure the next 50 years will be as eventful as the first half-century! ([www.thermoking.com](http://www.thermoking.com))