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Inside the world of refrigerated containers

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DEEP FREEZE ON THE HIGH SEAS

There are the refrigeration systems we see and use daily and those we don't. In the middle of the ocean, refrigerated containers in their millions are transporting fresh and frozen produce around the globe, writes ***Sean McGowan****.*

According to the World Shipping Council, the global refrigerated shipping container fleet reached about 2.1 million TEU (20-foot equivalent units) in 2012, representing a little over 6 per cent of the total global container fleet that measures in excess of 33 million TEU.

These containers are carried by liner ships (container vessels) that number over 6,000 globally, each with the capacity to carry several warehouses worth of goods.

Commonly referred to as "reefers", refrigerated shipping containers allow us to transport everything from meat, fruit, vegetables and dairy products to temperature-sensitive chemicals and pharmaceuticals across Australia, our region and indeed the world.

Developed following the containerisation of shipping in the 1950s, refrigerated containers have become the main method of transporting refrigerated and frozen goods over the oceans.

ANATOMY OF A REEFER

Willy Yeo, director of marketing for global container refrigeration at Carrier Transicold, says most container refrigeration systems are of the front-wall design, a configuration invented by Carrier 50 years ago.

"These fit within a narrow steel frame, approximately 8 by 8.5 feet [2.4 by 2.6m], that cleanly bolt to the front wall of an insulated shipping container."

Standard refrigerated containers are 40 feet (approximately 12m) in length, with 20-foot and 10-foot versions also available.

"Ownership of refrigerated containers today is fairly evenly split between shipping lines and leasing companies that provide shipping containers to container shipping lines," says Yeo.

Every container has a unique number for identification purposes, and is tracked by each movement.

For example, HLXU 3721738 is a valid Hapag-Lloyd shipping number – where HXL is the owner code, U is the category (reefer), 372173 is the serial number, and 8 is the check digit.

No two containers will ever have the same number.

Although the refrigeration systems serving these containers are like typical refrigeration units – with controls, compressor, condenser and evaporator – they differ in that they can control the interior temperature from anywhere between -35°C to 35°C, with a tolerance of ± 0.2°C, depending on the cargo.

Specially designed units for deep freeze, which often transport fish such as tuna, can pull down to -60°C.

The internal lining of a container is typically stainless steel, with the floor raised in a T-section to allow air flow. Air is delivered along the floor section and is returned back over the top of the load in a continuous cycle.

And because the container is air and water tight, the internals of the container are pressurised constantly, ensuring a consistent air flow across the cargo surface.

Traditional refrigerated containers are designed to plug into and operate on the power supply of container

Reefers are not converted dry containers – they are specifically manufactured and conform to standard ISO container dimensions.

ships, but recent advances in solar PV have seen the emergence of solar-powered units for use on land.

Electrically, refrigerated containers feature automatic phase correction, microprocessors and full data record. Most units today are also fitted with GPS to allow access to unit operating condition during the voyage, including real-time temperature readings.

Once off-loaded from the ship, the container is transferred to a truck for ground transport and will typically be powered by a portable generator set until the cargo is off-loaded and the container is returned to port to await further service.

Most traditional refrigerated shipping containers are still operating on HFC refrigerants such as R134a and R404A.

However, various environmental actions are moving the industry towards the adoption of lower global warming potential (GWP) refrigerants. For instance, HFO refrigerant blends such as R513A are being adopted by some fleets as a replacement for R134a. R452A is being used as a replacement for R404A.

Others have turned to natural refrigerants. After a number of years of successful trials, CO_2 is becoming more popular.

MODES OF OPERATION

According to Carrier Transicold, refrigeration units serving refrigerated containers have four main modes of operation: chill, heating, frozen and defrost.

When the temperature set-point is above -10°C, the unit is said to be in chill or perishable mode. During perishable operation, the heating mode may also be active. The controller uses a sensor placed in the supply air, which is the coldest air inside the container, to deliver a constant supply air at set-point.

In Carrier Transicold systems, the controller can adjust the cooling capacity automatically by opening or closing a variable valve that is in the refrigerant flow path returning to the compressor. This valve is called a stepper motor suction modulation valve (SMSMV).

A REEFER TECH'S PERSPECTIVE

As a third-year apprentice in the HVAC&R industry, Bridie McDonald has experienced a broad range of refrigeration and air conditioning applications, but it's been the reefer industry that has taken her interest most.

After starting out in 2014, McDonald began working on installing domestic split systems before progressing to the service and maintenance of split and ducted systems, ice machines and pharmaceutical refrigerators.

"Working in residential applications for a few years, I realised it wasn't exactly my type of thing," she says. "I took some time off to review my future career goals and explore different parts of the HVAC&R industry."

In early October 2017, McDonald came across an opportunity to work with transport refrigerated containers.

"As I was taught, a vapour compression system is almost always the same on many applications, just with some components added or removed," she says. "Refrigerated containers are the same – the only real difference is that they can be transported easily."

Working with South West Containers, based in Sydney's south-western suburbs, McDonald now spends her days maintaining and repairing reefers.

"Refrigerated container faults are easier and quicker to diagnose, you just have to know what you are looking for. Most components are easily accessible from the exterior of the container, but if there isn't enough room to move around outside (for example, if the container is pushed up against a wall) it can be hard to change parts."

While McDonald says that the refrigeration cycle and components are easy for any technician to understand, the electrical components involved can throw curveballs to those unfamiliar with them.

"Electrical components and wiring diagrams can be very complicated upon viewing, to match or trace the circuit physically," she says. "Every brand has its own electrical layout, so it's hard to explain without physically showing it."

Since starting in this part of the industry, she has seen first-hand how small businesses rely on reefers for their stock – from butchers and bakers to farmers and florists.

"I occasionally work at intermodal terminals, but would love the opportunity to work on the main ports throughout Australia as well as travel on ships when breakdowns occur," she says.

McDonald kindly agreed to answer a few questions for us in our Smoko With section. Check it out on page 28.

Although the refrigeration cycle and components will be familiar to fridgies, the electrical components can be harder to understand.

Because the interior fans circulate air inside the cargo space, the temperature can vary depending on the cargo temperature. If the supply air gets too cold, the controller will turn off the refrigeration unit and activate heating mode, in which electric heaters will warm the circulating air to bring the temperature back to set-point. The controller's ability to automatically manage supply-air temperature is key to avoiding frosting or freezing damage to cargo and maintaining perishable quality in transit.

At any set-point of -10°C or lower – frozen mode – the controller manages the box temperature by way of the return-air temperature sensor. Because the return air is the warmest air inside the container, the cargo temperature will be at set-point or below when the return-air temperature is also at set point.

In frozen mode, the heating mode is locked out and the SMSMV is 100 per cent open when the compressor is running, which means the unit is operating at full capacity until set-point is achieved. Once the set point is reached, the controller cycles the compressor off and the interior fans continue to circulate air until the air temperature is above set point and the compressor switches back on. The controller continues to cycle the compressor off and on to maintain the set point temperature ±0.5°C.

During the refrigeration process, moisture from the cargo within the circulating air of the refrigerated container is trapped on the evaporator coil and turns to ice. To stop the evaporator coil becoming blocked and preventing good air circulation, the controller will periodically turn off all components and then activate the electric heaters, which are located underneath the evaporator. The hot air rises, melting the ice, and the water drips down into a tray and is drained outside.

Once the defrost cycle is complete, refrigeration resumes. The automatic defrost mode varies the defrost cycle, depending on cargo and cargo space conditions, although the user can manually set the defrost timing cycle if required.

As well as these four modes, more advanced options can be achieved by adding sensors and other technology to help control the internal humidity as well as the balance of oxygen (O_2) and carbon dioxide (CO_2). This helps to reduce the ripening and spoilage of perishables.

THE QUEEN OF COOL

Imagine having such a passion for something that you would be prepared to devote the prime years of your life to it.

That's the story of Barbara Pratt – dubbed the Queen of Cool – who spent much of her twenties living inside a refrigerated shipping container. Her work helped revolutionise the reefer business and led to many advances in both the technologies and methods used to transport refrigerated goods around the world.

Pratt grew up on an orchard farm before attending New York state's Cornell University. Knocking back opportunities for post-graduate education, she joined Sea-Land, a shipping company founded by the inventor of shipping containers, Malcolm McLean.

It led to her spending years working in a "Mobile Research Laboratory" – a modified, 40-foot shipping container that was part science lab, part mobile home. It enabled Pratt and her colleagues to travel the world studying the impact of transportation on fresh and frozen products.

These findings led to all sorts of innovations we take for granted today, from reefer container design through to packing methods and customisation to achieve the particular ventilation, airflow rates and temperatures that fresh produce requires to sustain transportation.

Today, Barbara Pratt is the director of refrigerated technical services for Maersk Line in North America.

Source: www.maersk.com

Also available is an atmosphere control technology to control O_2 and CO_2 levels, and an integrated capability to remove ethylene, a hormone produced by fruit that can accelerate ripening. Other modes are available to fine-tune performance for energy efficiency based on the specific commodity being transported.

MAINTENANCE AND SERVICING

A typical refrigerated container may take several voyages each year, and because of the high value of the cargo carried, reliability is critical.

From the moment a container is loaded with cargo, the container's interior temperature is monitored daily. Modern software can now also monitor the performance of the refrigerated container.

"While the refrigeration system is in use, the software monitors the operation of fan motors, sensors, compressors, valves and more to see if the unit is running within normal parameters," says Yeo.

Given their use and the conditions in which they operate, reefers are built tough. They usually fail due to physical damage to both the refrigeration unit and the container itself. Water ingress can also cause electrical failure, if the control box and components are not sealed from the elements. And regular checks are vital.

As service warranty agents for the four major reefer manufacturers, Craig Lyttle, Australia/New Zealand technical/service manager for JPC Reefer Services knows a thing or two about getting reefers back into service.

"The life of a refrigerated container is approximately 10 to 12 years," says Lyttle. "Over that time they are handled and shifted many times by forklift, truck, train and ship.

"Before each trip and cargo loading they are placed for a pre-trip inspection (PTI) to ensure they are capable of carrying cargo to destination. This involves checking over the units for any impact damage, corrosion related issues or machinery repairs."

Pre-trip inspections usually occur portside.

Lyttle says the main maintenance issues he sees with refrigerated containers are salt-water corrosion, water ingress and impact damage.

If a problem arises at sea, he says all shipping lines carry spare parts onboard their vessels to allow the unit to be repaired to prevent loss.

"Loaded units both on land and on vessels take priority and have strict time constraints," he says. "The shipping industry is 24/7 and does not stop."

Editor's note: HVAC&R Nation thanks Carrier Transicold and JPC Reefer Services for providing the information used in the preparation of this article.

If you or someone you know works in an interesting, hidden part of the HVAC&R industry, we'd love to hear about it. Email mark.vender@airah.org.au All submissions received will be considered, though publication cannot be guaranteed. ■

TOP 10 WORLD CONTAINER PORTS

You might not be surprised to know that China has seven of the top 10 container ports in the world, with South-East Asia having nine of the 10.

Rank	Port	Volume 2016 (million TEU)
1	Shanghai, China	37.13
2	Singapore	30.90
3	Shenzhen, China	23.97
4	Ningbo-Zhoushan, China	21.60
5	Busan, South Korea	19.85
6	Hong Kong (SAR), China	19.81
7	Guangzhou Harbor, China	18.85
8	Qingdao, China	18.01
9	Jebel Ali, Dubai, UAE	15.73
10	Tianjin, China	14.49

Source: World Shipping Council

Port of Shangai, China

In comparison, Sydney's Port Botany overtook Melbourne as Australia's largest container stevedoring port in 2016–2017, processing a record 2.5 million TEUs. It was closely followed by Melbourne with 2.4 million TEUs.