FRESH CONNECTIONS
YOUR REEFER GUIDE

CMA CGM GROUP

APL


APL

Introduction

An estimated 25% of the world's produce is never consumed – and often inefficient transportation systems between the grower and consumer are the reasons why.

APL has prepared this guide to help reverse this trend, because as the industry's recognized leader in shipping refrigerated and climate-controlled cargo, we know what a positive difference using proper handling techniques can make.

From the field to the marketplace, each of us has a vital role to play in protecting and preserving all of the world's produce. We hope you'll find the instructions in this guide helpful and that you'll join us in our quest to help more temperature-sensitive product arrive at their final destination safely, efficiently and with a minimal loss of quality.

ABOUT APL

APL is a global leader in containerized ocean shipping. For more than 170 years, we've been connecting businesses around the world via a wide range of services, ports and specialized solutions.

We're also one of the world's foremost refrigerated shipping experts. We pioneered the use of digitally-controlled, refrigerated containers and specialized generators that would allow the refrigerated units to move on double-stack container trains. We were the first ocean carrier to ship asparagus from California to Japan – as well as the first to ship seafood from India to the United States and live trees from California to the Arabian Gulf region. We launched SMARTemp™, the industry's first satellite tracking service that continually monitors the temperature and humidity of refrigerated containers carrying sensitive cargo.

Just as important, we've spent years working closely with industry stakeholders to develop the procedures and equipment that shippers like you need to transport temperature-sensitive product safely and reliably anywhere in the world.

Our specialized refrigerated services offer:

- some of the industry's most technologically advanced refrigerated containers, including several high-capacity designs
- a wide range of origin services such as source loading at the packing house, storage facility or slaughter house
- a variety of climate-controlled intermodal shipping options with frequent arrivals and departures
- continuous in-transit monitoring of factors such as sanitation, packing, air circulation and temperature
- best-of-class visibility tools such as eBusiness (the industry's first customizable website), which provides 24-hour, real-time status of all your active reefer shipments
- the industry's first satellite container tracking and temperature monitoring service, SMARTemp™

For more information about these services, we encourage you to contact your reefer account manager. They'll work closely with you to determine your needs and recommend the best solution to meet your requirements.

KNOWING YOUR CARGO

Maintaining freshness is of utmost importance during shipment. Perishable commodities need to be shipped under optimum conditions to ensure they arrive in prime form. Perishable commodities can be broadly categorized as:

Chilled cargo	Frozen cargo	Special and miscellaneous cargo
Fresh fruit and vegetables	Frozen meats and poultry	Chemical and biological products
Fresh meats, poultry and seafood	Frozen prepared foods	Batteries
Dairy products and eggs	Frozen concentrates	Photographic film and materials
Fresh juices	Frozen fruits and vegetables	Pharmaceuticals
Confectionery products	Ice-cream	Tobacco products
Bulbs, live plants and cut flowers	Frozen seafood	Live animals e.g. bull frogs

Chilled Cargo

Chilled cargo refers to commodities which need to be shipped above product freezing temperatures. Some chilled cargoes are more sensitive than others because their characteristics and the factors affecting their shelf lives vary. Other chilled commodities have relatively short shelf lives and require careful attention during transportation.

Reefer containers will automatically control refrigeration using the supply air sensor to detect and manage temperatures within a 0.5°C (0.9°F) range, or better, under most conditions.

Types of chilled cargo include:

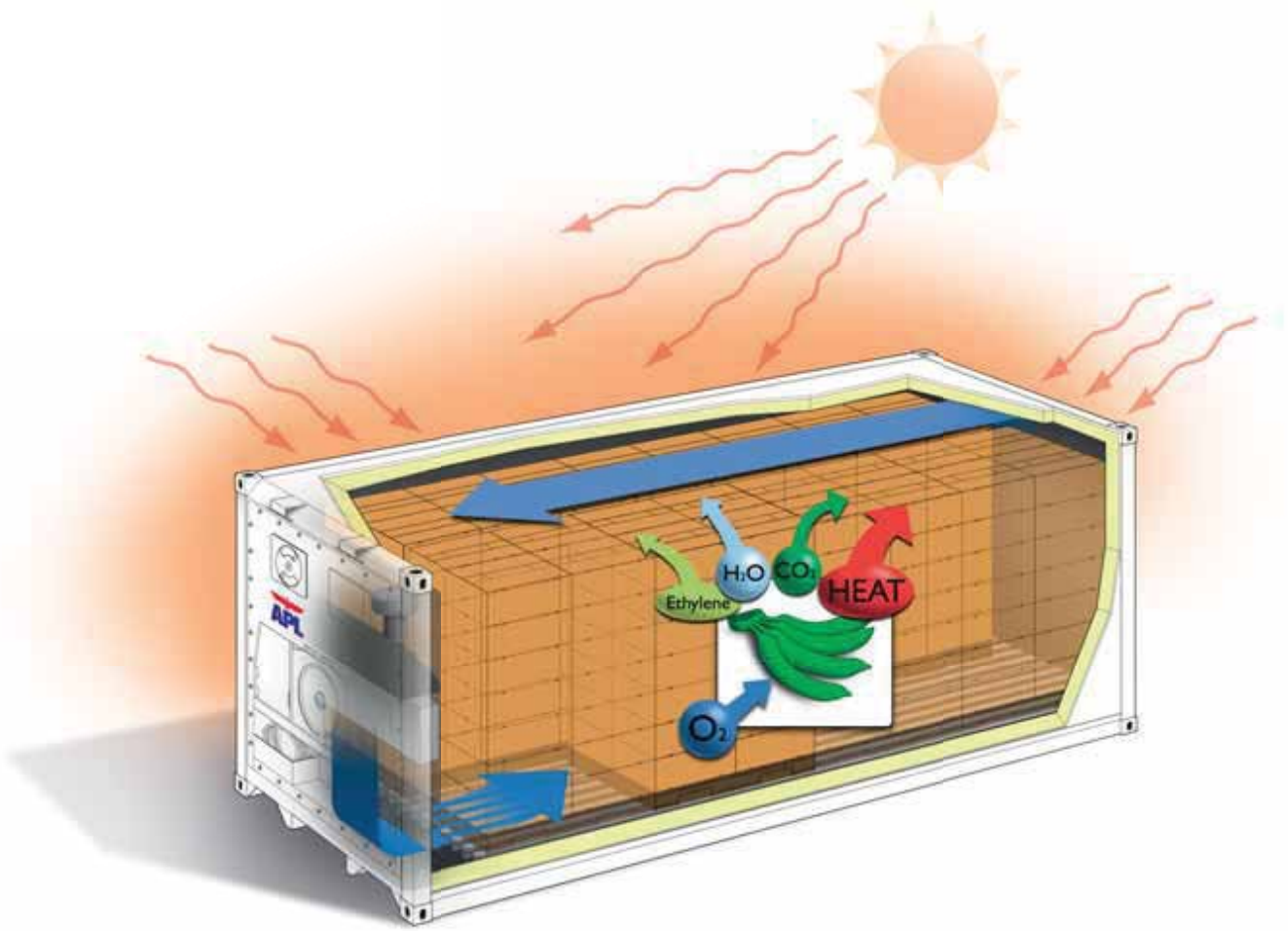
- Fresh fruit and vegetables
- Fresh meats, poultry and seafood
- Dairy products and eggs
- Fresh juices
- Confectionery products
- Bulbs, live plants and cut flowers

Horticultural commodities

A key component of chilled cargo consists of horticultural commodities. Horticultural commodities continue to "live" after harvesting, and refrigeration is crucial to ensure that the product retains its commercial value from harvest to its final destination. The key factors contributing to the shelf life of horticultural commodities are:

Respiration

Fruits and vegetables continue to live and breathe after harvest, consuming oxygen, generating heat and giving off gases such as carbon dioxide and moisture. This respiration process utilizes resources and causes changes that influence the commodity's value, flavor, quality, color, texture and water content.



All fruits and vegetables have different respiration rates, which is part of the natural ripening process. For example, commodities such as potatoes and onions have low respiration rates and enter into a dormant state when harvested. Other commodities such as broccoli and asparagus, which are harvested during an active phase of growth, have relatively high respiration rates, as do products with short post-harvest lifespans.

Relative respiration rates of selected commodities:

Respiration Rate	Commodity
Very low	Dates, dried fruits, nuts
Low	Apples, citrus, garlic, grapes, kiwi, onions, potatoes (mature), sweet potatoes
Moderate	Apricots, bananas, cabbage, carrots, cherries, figs, lettuce, mangoes, nectarines, peaches, pears, peppers, plums, potatoes (immature), tomatoes
High	Avocados, blackberries, cauliflower, lima beans, raspberries, strawberries
Very high	Artichokes, brussel sprouts, cut flowers, green onions, snap beans
Extremely high	Asparagus, broccoli, mushrooms, peas, spinach, sweet corn

Temperature

Temperature is the most important factor in preserving the freshness and quality of harvested commodities because the rate of respiration is directly proportionate to the rate of deterioration, which increases exponentially as temperatures increase. As a general rule, for every 10°C (18°F) increase in temperature, the rate of deterioration increases two to three times over.

Maintaining optimum temperatures in refrigerated transportation will maximize shelf life and quality, because it can:

- Reduce respiration
- Slow down moisture loss and wilting
- Prevent spoilage due to bacteria, fungi and yeast
- Retard undesirable growth such as sprouting

Avoidance of temperature variations is critical because temperatures that are too high or too low will lead to undesirable outcomes.

Exposure to high temperatures can:

- Accelerate water loss
- Produce ethylene
- Produce disease-forming organisms
- Affect the physiological state of the product
- Cause uneven ripening, surface scalding and decay

Exposure to low temperatures can cause:

- Chilling or freezing injury
- Surface pitting and watery areas
- Discoloration

Ethylene production

Ethylene gas is a natural by-product of perishables during respiration. If managed properly, it can be used to control the ripening process. Produce vary in their sensitivity to ethylene levels and concentration, which together with the control of temperature, oxygen and carbon dioxide levels, play a vital role in the freshness of the commodity. Some commodities are sensitive to ethylene concentrations of as low as 0.1 ppm (parts per million) when exposed over long periods of time.

Sample rates of ethylene production:

Rate	Commodity
Very low	Artichokes, asparagus, cauliflower, cherries, citrus, grapes, jujubes, leafy vegetables, most cut flowers, pomegranates, potatoes, root vegetables, strawberries, watermelons
Low	Blueberries, cranberries, cucumbers, eggplant, okra, olives, peppers, persimmons, pineapples, pumpkins, raspberries, tamarillos
Moderately high	Apples, apricots, avocados, bananas, cantaloupes, feijoa, figs, honeydew melons, kiwi, mangoes, nectarines, papayas, peaches, pears, plums, tomatoes
Very high	Cherimoyas, passion fruit, sapota

The key factors affecting the rate of ethylene production in the commodity include:

- Temperature
- Maturity
- Physical injury
- Environmental pollutants

Water loss

In horticultural crops, water loss after harvest has a direct impact on their life cycle and is a major cause of deterioration. Perishables retain their market value and are deemed as of better-quality if water is not lost during the course of shipment. A higher rate of water loss will generally be experienced by:

- Leafy vegetables with larger exposed surface areas (in comparison with fruit)
- Plants that have been bruised or cut (in comparison with undamaged plants)

Water loss can be minimized by ensuring:

- Lowest safe temperature
- High humidity of 85% - 95%
- Rapid pre-cooling
- Appropriate packaging

Frozen Cargo

Generally, frozen cargo refers to commodities or food stuffs which need to be shipped and stored at -20°C (-4°F), the optimum temperature for protection against spoilage and the growth of disease-forming organisms.

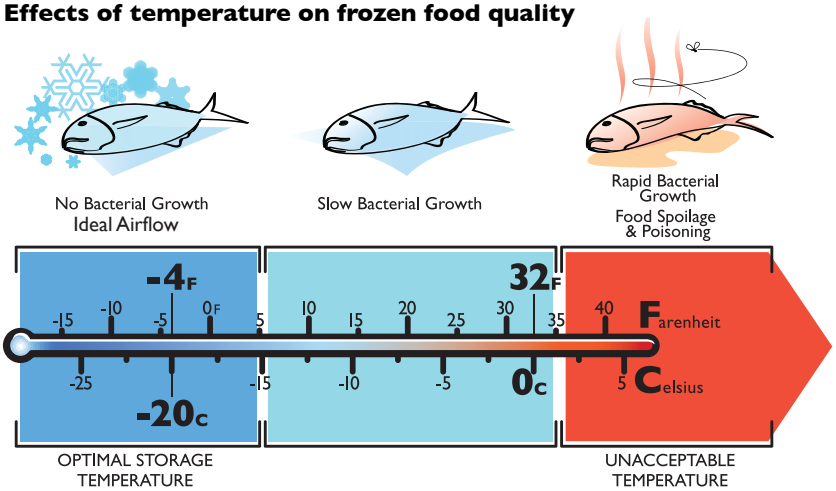
Certain frozen cargo needs to be transported at temperatures lower than -20°C (-4°F) to maintain quality, texture and flavor. Commodities with a high fat content, such as ice-cream and surimi, should be transported at -26.1°C (-15°F) or lower.

Low temperatures preserve the quality of frozen food (e.g., aroma, flavor, texture and appearance) and protect it from spoilage. However, proper temperature management of frozen commodities can only be achieved if the products are properly frozen, packaged and correctly stowed for transit.

Types of frozen cargo include:

- Frozen meats, poultry and seafood
- Frozen prepared foods
- Frozen concentrates

Effects of temperature on frozen food quality



The key factors affecting the shipment of frozen cargo include:

Freezing

The freezing process is an effective means of preserving the quality of frozen food because it inhibits micro-organisms and slows most enzyme activities and oxidative processes. Food should be solidly or almost solidly frozen. An unfrozen core or a partially frozen zone, will lead to deterioration in texture, color, flavor and other properties.

As a rule:

- Fast freezing leads to superior product quality
- Slow freezing results in the formation of large ice crystals that rupture cell walls and result in soft, mushy products

Thawing

Nothing is more detrimental to frozen food than repeated freezing and thawing. Proper temperature management is crucial because temperature fluctuations that cause thawing can be damaging.

Packaging

Appropriate packaging and glazing can protect most foods from freezer burn (surface drying that produces unsightly appearance and nutrient loss), bacterial contamination and the effect of oxygen. Packaging material should not only be impermeable to water vapor and oxygen, but also to volatile odors and substances.

Pre-cooling*

Proper pre-cooling of containers for the shipment of frozen cargo helps to prevent:

- Surface thawing
- Freezer burn
- Condensation

As part of our quality-control procedures, APL requires that the temperature of frozen commodities be 15°F (-9.4°C) or less at the time of loading.

Stowing

Frozen cargo should always be stacked as a solid block, to allow air to circulate around the periphery of the load. For stowage of cargo in containers with flat-sided walls, slightly loose stowage is necessary to facilitate air circulation, because cartons that are packed too tightly across the space may give rise to hot spots and cause problems.

Ventilation

The fresh air vent must always be closed tight and sealed for all frozen cargo shipments.

*Please refer to page 14 for container pre-cooling guidelines and requirements.

Special and Miscellaneous Cargo

Non-food products that need temperature and/or humidity protection during transportation are classified under this category. It is important to strictly adhere to any special handling instructions regarding the packaging, stowage, temperature and humidity management for these cargoes in order to maintain product quality.

Types of special and miscellaneous cargo include:

- Chemical and biological products
- Batteries
- Tobacco products
- Medical supplies

Chemicals and biological products such as medical supplies, photographic materials, cosmetics, chemicals and resins are more fragile than some perishables and must be treated with the highest level of care.

The following factors are generally taken into consideration when transporting such cargo:

Temperature management

These types of products are extremely sensitive to temperature changes. Chemical reactions can occur if temperatures are not kept within a prescribed range. Monitoring needs to be properly managed at all stages from pre-cooling to packaging to stowage.

Pre-shipment handling

Products that are especially susceptible to damage will be handled with extra safety precautions to ensure smooth delivery.

Sanitation

Sanitary procedures are carried out every step of the way to prevent medical products from bacterial contamination.

Packaging and stowage

There are different packaging specifications made for varying products' characteristics and certain products may even require special packaging. In addition, stowage is more critical than usual because of the fragile nature of these products.

Product compatibility

Most special and miscellaneous cargo cannot be shipped in the same container. Always follow manufacturers' instructions and rest assured that our highly-trained personnel will do the necessary research to ensure that your shipment is in safe hands.


APL
APL
APL
APL
APL
APL

PRODUCT HANDLING

Pre-Shipment

Many factors influence product shelf life, from sanitation and pre-cooling to stowage and storage temperature. Proper product handling is crucial during shipping, storage and processing of cargo.

Planning

As our valued customer, you can expect APL to work closely with you to understand your needs and service requirements before your cargo is booked. The following factors are taken into consideration in order to provide you with the best possible service:

- Equipment type
- Product quantity and weight
- Transit times
- Departure and arrival times
- Market and regulatory requirements

APL also determines the most cost-effective and efficient service to meet your needs. Our sales representatives have access to the expertise of APL reefer specialists, as well as many other highly trained professionals throughout the organization.

APL works in partnership with your suppliers, equipment manufacturers and other vendors to develop special handling procedures and select the proper equipment for door-to-door transportation. By maintaining constant contact with you, APL ensures continuous improvement and is able to make any necessary service adjustments to help serve you better in the future.

Booking

During the booking process, customers should provide the following critical shipment information:

- Product(s) being shipped
- Origin and destination
- Quantity, weight and cubic measurement
- Type of packaging: boxes, drums, pallets, hanging carcass, etc.
- Preferred carrying temperature (specify in °F or °C)
- Fresh-air exchange requirements (specify in cfm or cmh)
- Preferred relative humidity setting (specify in %)
- Regulated or controlled atmosphere requirements
- Available pick-up date at origin
- Required delivery date at destination
- Special handling requirements (e.g. cold treatment)

Once all the necessary information is available, APL handles the rest.

- An APL customer support representative enters shipment information into the computer system.
- APL personnel select the most appropriate vessel voyage and assign a container that meets the product's requirements.
- APL personnel review shipping information to ensure that the over-the-road cargo weight is within legal limits and to recommend and confirm appropriate temperature and fresh-air exchange settings.
- Pick-up and delivery dates are coordinated. APL personnel confirm space reservations and assign the shipment a booking number.
- As the container leaves the gate, a final check of the temperature and function of refrigeration unit will be done.

Pre-shipment handling

APL serves as your partner throughout the quality assurance process to ensure product quality at destination.

- The shipper arranges for preparation of the cargo, providing instructions for pre-cooling of containers to the required carrying temperature as appropriate.
- APL maintenance and repair staff members conduct a complete diagnostic check of the refrigeration unit and calibration as needed. Our staff also inspects the container for damage and thoroughly cleans the interior.
- The shipper then notifies the trucker to pick up the container. Next, the APL yard personnel ensure the fresh-air exchange ports, carrying temperatures and humidity are set correctly.
- The trucker picks up the container and drives it to the place of loading. Upon shipper's satisfaction and acceptance, cargo is then loaded and the container is sealed.
- A decal is then placed on the front of the container to list the container number, vessel and voyage, name of the commodity and temperature and fresh-air exchange setting requirements.
- APL reefer specialists periodically check the container for proper temperature, fresh air exchange and other settings, ensuring the reefer is in the best operating condition.

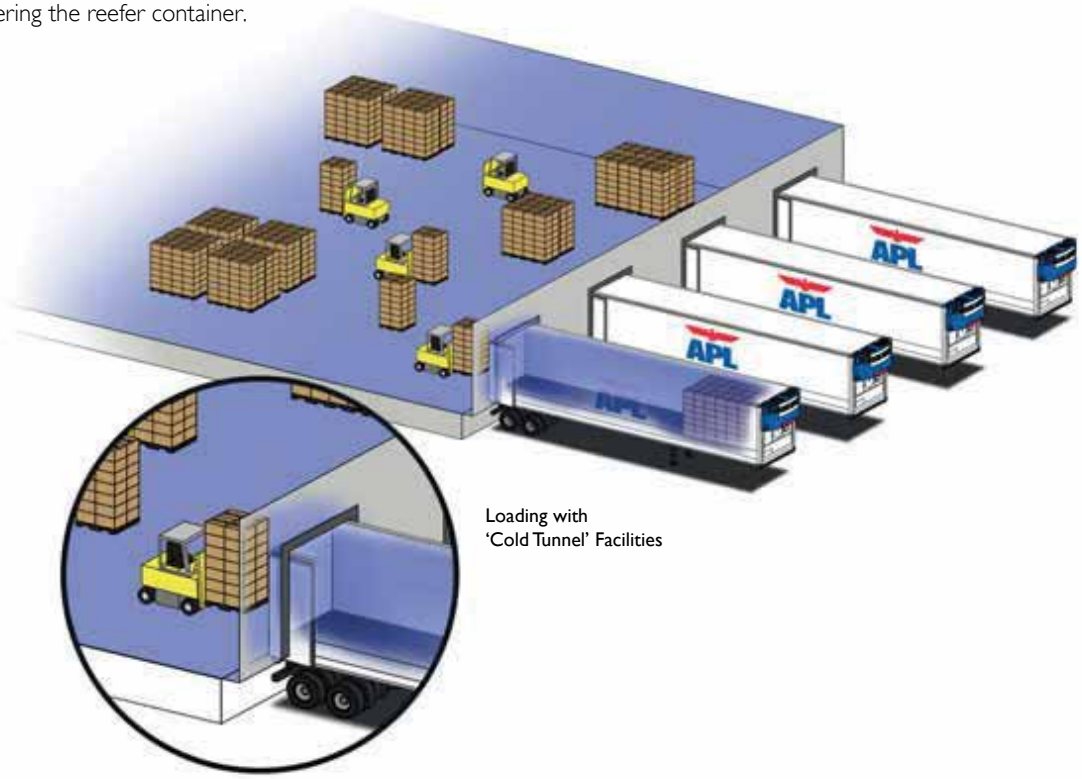
Pre-cooling

Cargo pre-cooling

- Proper pre-cooling of product is essential, because it rapidly removes heat from commodities before shipping, storage and processing.
- All refrigerated cargo should be pre-cooled to the recommended carrying or storage temperature before it is loaded into a container.
- Proper product pre-cooling reduces the rate of water loss and spoilage for many perishables and helps maintain freshness and quality.
- Remember: Reefer containers are built to maintain the temperature of products, not to decrease their temperature.

Container pre-cooling

- Transferring a cold product to a warm container can result in surface thawing and freezer burn. When necessary, the container should be pre-cooled to the appropriate carriage temperature before loading. Frozen products should be loaded rapidly, especially in warm weather when ambient temperature may be high.
- Pre-cooling of the reefer container is required only when a proper loading bay (i.e. with 'cold tunnel' loading facilities) is available and the temperature in the cold store and in the container is identical.
- Proper loading facilities, as shown below, consist of a tight insulated duct between the cold store and container to prevent warm, highly humid, ambient air from entering the reefer container.

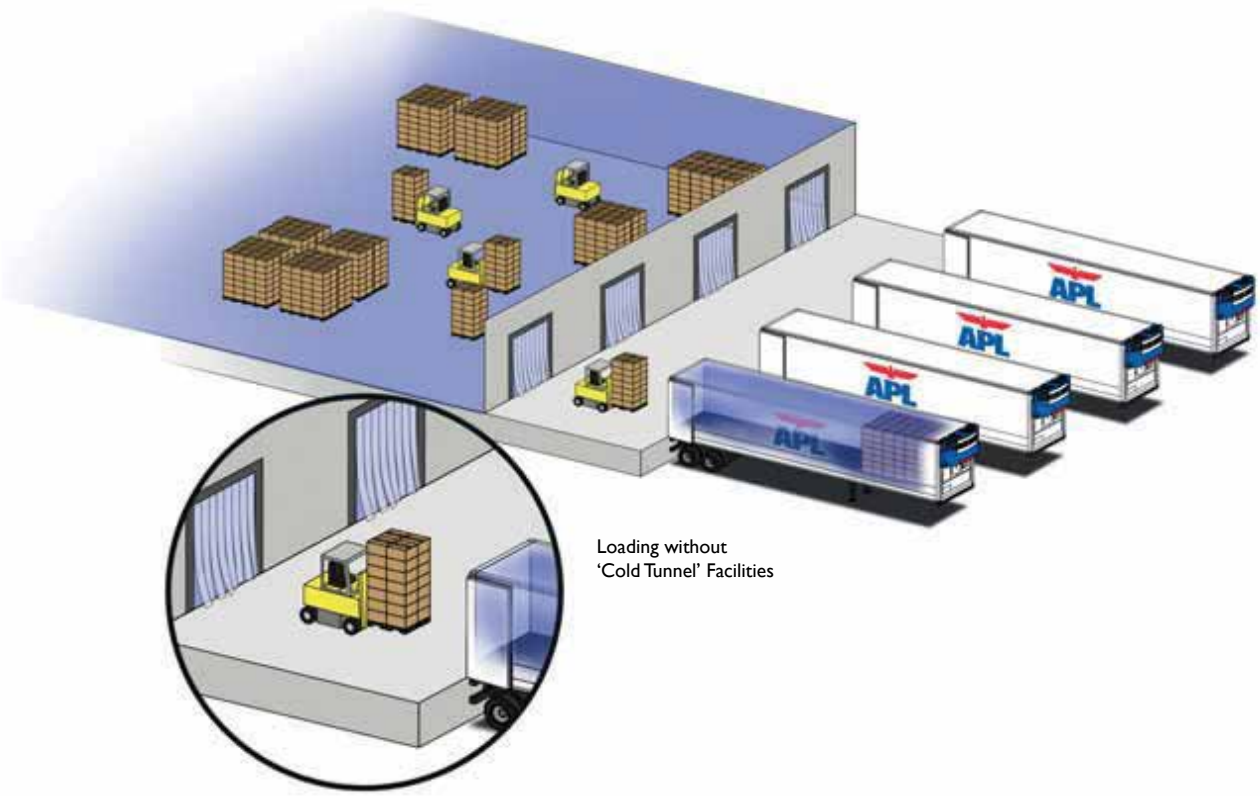


Loading with
'Cold Tunnel' Facilities

Reefer containers should NOT be pre-cooled if no proper loading facilities are available due to the following reasons:

- Condensation on the evaporator coil. This occurs when warm, humid air enters the container during stuffing. It results in the formation of ice, which needs frequent defrosting and eventually affects the cooling capacity that is required for the cargo.
- High condensation on the interior surfaces of a reefer container (such as the T-floors and sidewalls). This occurs when hot, humid air enters the container during stuffing. It eventually results in ice build-up for frozen cargo and causes damage on packages for perishable cargo. In some cases, condensation on perishables can even contribute to the spread of disease. This often occurs in a tropical climate when open reefer cargo loading takes place in high-temperature and high-humidity environments.
- For frozen cargo, ice build-up is one of the factors that causes overweight reefers, and in some cases, results in poor air circulation because any ice that forms on the T-floor and sidewall can restrict airflow, especially in a situation where the container drain plug is clogged.

Instead, it is recommended that the container is only cooled to just above dew point so as to remove heat from the walls.

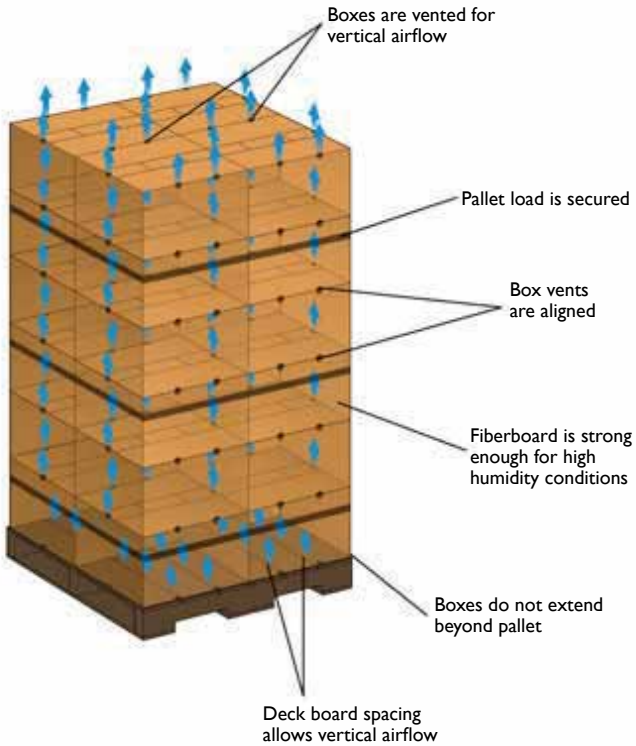


Loading without
'Cold Tunnel' Facilities

Packaging

Packages must be properly designed, constructed and stowed to protect the product.

- Protection from rough handling: Packaging must be able to withstand a variety of handling and environmental conditions, including those encountered during the inventory, marketing and distribution processes. Improperly designed cartons are more susceptible to collapse under rough handling and high humidity conditions.
- Stacking strength: Cartons must be designed to withstand the weight of other stacked cartons. Overloading cartons and stacking them beyond their designed limits can cause damage to the cartons and their contents.
- Protection from moisture loss: Most packages must be able to tolerate exposure to high relative-humidity levels during transportation and marketing.
- Aiding temperature management: Appropriate vent cartons for chilled cargo promote proper airflow through the container. Cartons should be vented on the top and the bottom to allow air to circulate upwards through the load.



Stowage

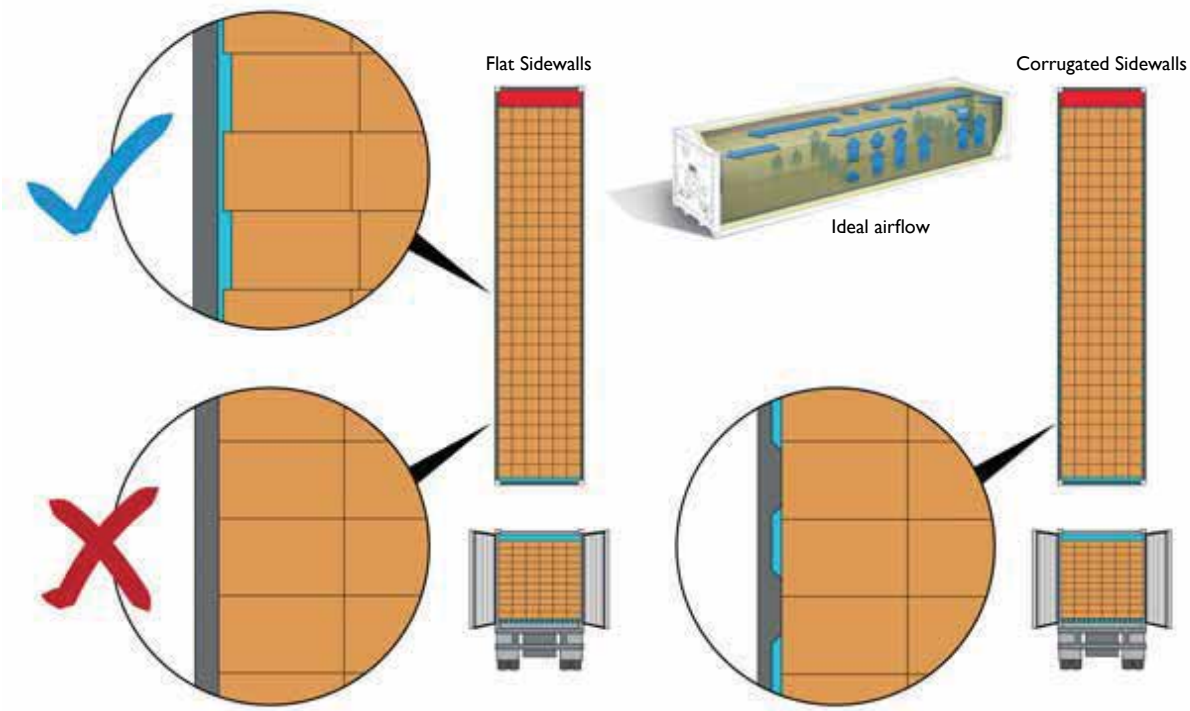
In order to maintain the required airflow for desired temperatures, proper stowing is essential. Critical factors to maximize post-harvest life include having a clear stowage plan and understanding how stowage patterns affect airflow in the container. For all stowage and cargo loading, it is important to cover the entire floor with pallets, boxes or other materials, and load them below the red line.

Chilled Cargo such as fruits and vegetables generates heat during respiration. As a result, it is essential to ensure that large proportions of circulating air pass through (and not just around) the stow to provide good contact with all parts of the load. Chilled produce needs to be block stowed or stacked as a solid block, without leaving any space between the cargo - preferably with vent holes aligned to facilitate the reefer container's bottom air (vertical flow) delivery of airflow passing through the cargo. Occasionally, it may be necessary to brace a chilled load to stabilize it in transit. In such cases, APL recommends a refrigerated container equipped with cargo tie-down rings and restraining devices.

Frozen Cargo should always be stacked as a solid block, leaving no space between packages or pallets. In addition, air must be able to circulate around the periphery of the load. It is necessary to ensure air can circulate **under**, **over** and **to each side and end** of the stow. When stowing produce in containers with flat-sided walls, slightly loose stowage is necessary for air circulation to allow refrigerated air to circulate evenly around the cargo and ensure that any heat penetrating the container does not come into contact with the load.

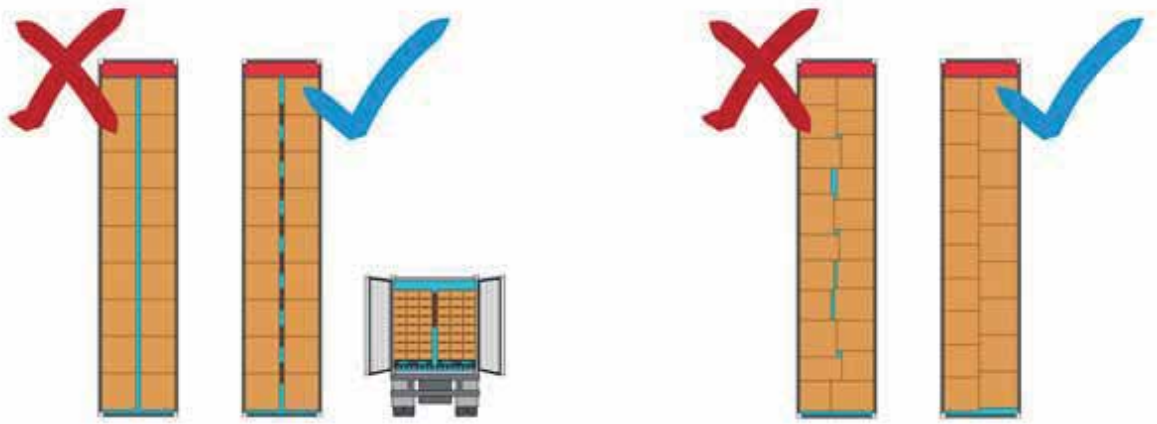
Block stowing: Hand-stowed cargo

- Stack cargo as a solid block. There should be little or no separation between the packages.
- Do not leave any space between cartons. Since air takes the path of least resistance in returning to the refrigeration unit, a gap between cartons can cause the cold air to short-cycle through the gap. When short-cycling occurs, part of the load may not benefit from the cold air, which may result in it being carried at less desirable temperatures.
- To facilitate air circulation for flat-wall containers, it is necessary to ensure cartons are not stowed too tightly against the side walls to ensure sufficient air circulation.
- Cover the entire floor with cargo.
- Leave enough space above and beneath the load for air to properly circulate.
- Do not stow cargo above the red line on the interior container wall.



Block stowing: Unitized cargo

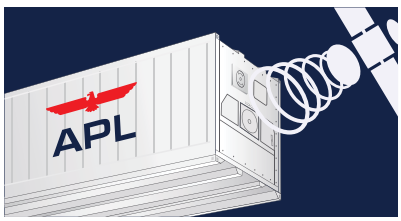
- Follow all of the instructions for hand-stowed cargo (listed above). In addition, follow the remaining three steps listed below.
- Stack cartons squarely, one on top of the other, so that the weight of each carton is evenly distributed on its four corners.
- Align the top and bottom carton vents so that air can flow properly through the load.
- Do not use shrink-wrap or other material that may block package vents and obstruct airflow.



Summary of correct loading and stowage requirements:

- Cargo is block stowed since air takes the path of least resistance.
- There are no gaps between items in the load, and the whole T-floor is covered so air is not short-cycled.
- Cargo level is below the red line with minimum space at the back of the container since lower airflow could cause hot spots.
- Cargo is not stowed too tightly against the side walls especially on flat (smooth) wall containers to prevent any heat penetrating the containers from coming into contact with the load, and allowing air to circulate around the periphery of the cartons.

SMARTemp



In Shipment

In-transit monitoring

- APL monitors the refrigeration unit regularly to make sure that it is running properly when it enters and leaves the container yard, when it enters the railhead, at the ocean terminal and on board the vessel.
- APL personnel routinely check the decal on the front of the container against the temperature and fresh-air exchange settings. Our specially trained personnel are quick to spot discrepancies and correct problems should they occur.
- A technician regularly checks a container's settings to make sure they are within prescribed limits. After checking the container settings, the information is recorded in a log to provide an ongoing record of readings for quality-control purposes.
- Carriage parameters such as temperatures, humidity and gas levels (e.g. oxygen) will be monitored closely to ensure optimal conditions.

SMARTemp™ real-time monitoring

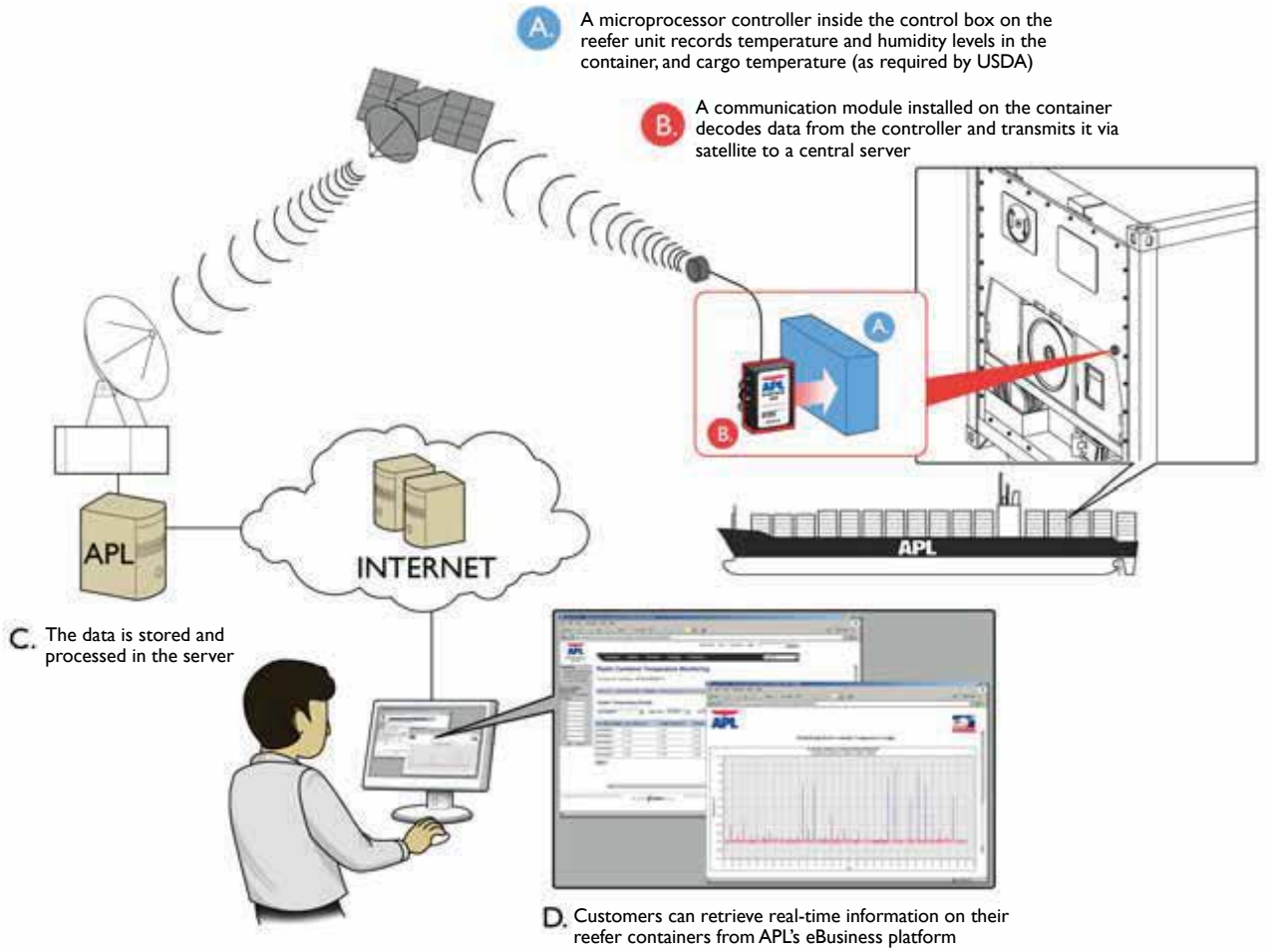
SMARTemp™ (Satellite Monitoring and Remote Temperature Tracking) provides real-time temperature and humidity information to our customers and is highly recommended for temperature-sensitive commodities. Real-time access to live temperature data grants greater visibility and protection capabilities over the shipment. As a result, exceptions can be addressed immediately by a team of professionals – a great value added service for shippers with zero tolerance for supply chain downtime.

Features:

- Continually monitors the temperature and humidity of refrigerated containers carrying sensitive cargo
- Utilizes low orbit iridium satellite constellation which, combined with proprietary software in the APL communication module, ensures signal integrity
- Access to "live" online information on container temperature and humidity levels, and cargo temperature
- Customizable frequency of data updates based on cargo type and handling requirements
- Data can be accessed with a BL or container number in a table format or exported to Excel with the option of a date range filter
- Immediate availability of trip temperature records for quality verification purposes
- Data can be archived for up to 2 months

Benefits:

- Added visibility of shipment with instant access to actual, real-time data provides greater peace of mind
- Enhanced cargo protection minimizes damage and financial loss, thus providing added assurance for high value commodities
- Unrivalled time, cost and quality advantages to shippers of products which have zero tolerance for supply chain downtime
- Instant alerts on any exceptions will be sent to APL's on-call cargo teams to provide immediate corrective action
- Convenience, time savings and cost savings are achieved as installation of separate measuring devices is not required
- Immediate access to data eliminates costly and time-consuming processes such as post-voyage cargo validation which is required for pharmaceutical cargoes



Cargo Delivery

- APL personnel conduct a thorough final check before the cargo is delivered to its end destination. By paying attention to the smallest details, APL is always able to deliver first-class results.
- The consignee arranges local customs clearance and notifies the trucker when the cargo will be available for pick-up.
- The trucker arrives to pick up the container at the APL port or terminal facility. In the case of store-door service, APL arranges a trucker, equipped with either an under-slung or clip-on generator set for delivery.
- As the container leaves the gate, trained APL personnel check the temperature and make sure the refrigeration unit is functioning properly for its final journey.

STATE-OF-THE-ART EQUIPMENT

APL stays on the cutting edge with the latest in refrigeration technology and continually incorporates the most advanced features into its containers. We have one of the largest and youngest fleets of reefer containers, with the most technologically advanced capabilities for precise temperature, relative humidity and atmosphere control.

APL containers are constructed to withstand the rigors of long transits.
Their features include:

- An easy-to-clean-interior made of sanitized aluminum or Muffler Grade Stainless Steel (M.G.S.S.)
- M.G.S.S. containers are welded and stronger for heavy-duty applications
- High internal volume capacity to provide maximum space for cargo
- Low tare weight to maximize payload
- Polyurethane foam insulation for greater thermal efficiency
- Minimal air leakage and low heat leakage to maintain optimum cargo temperatures

	M.G.S.S.	
Internal length	11,583 mm	38 ft
Internal width	2,294 mm	7.53 ft
Internal height	2,548 mm	8.36 ft
Tare weight	4,730 kg	10,427.87 lbs
Max gross weight	34,000 kg	74,957.17 lbs
Max payload	29,270 kg	64,529.3 lbs
Internal cubic capacity	67.7 m^3	2,390.8 ft^3

M.G.S.S. containers provide for optimal cargo loading with its large capacity and high payload.

Our young fleet of refrigerated containers will ensure:

- High cooling capacity and symmetrical bottom air delivery
- Cargo reaches optimum temperature and set point as quickly as possible
- Precise temperature control; microprocessor uses PID (proportional-integral-derivative) temperature control algorithm to regulate air temperature
- Even air and temperature distribution

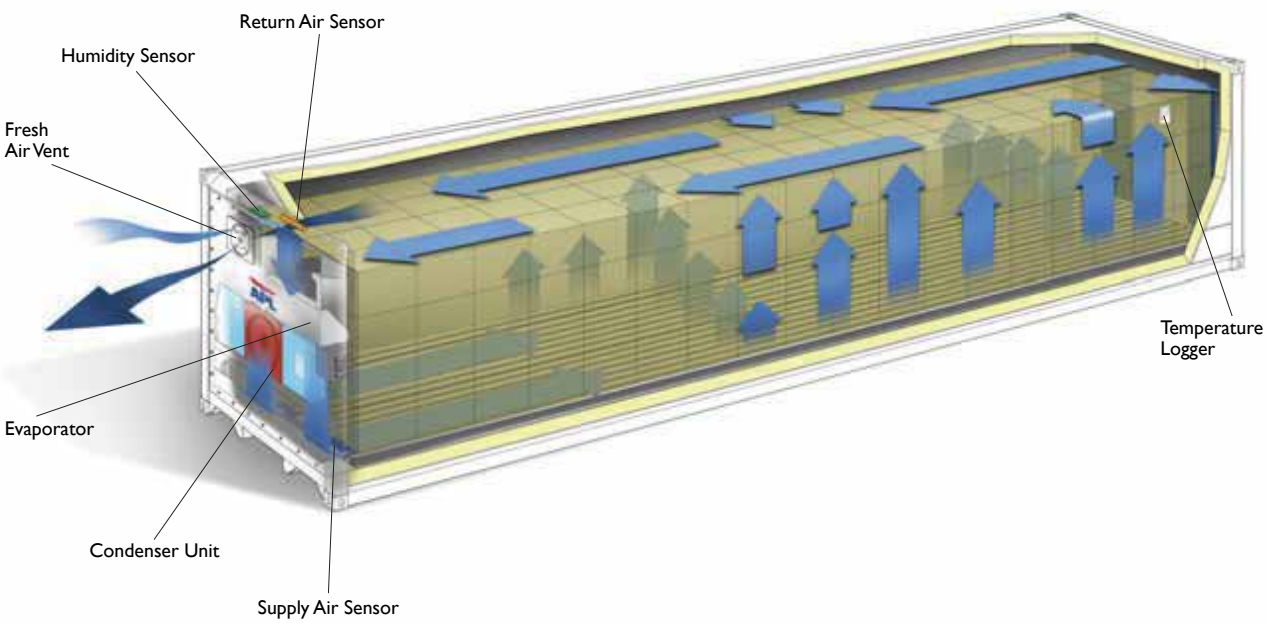
With APL reefer containers, you can be assured of superior cargo protection and consistent cargo quality with every journey.

Components of a reefer refrigeration system

All reefers need certain components to help circulate air, remove heat and manage product temperature. Most refrigeration units have excess cooling capacity to maintain product temperatures.

The refrigeration unit consists of the following:

- Compressor
- Condenser / fans
- Evaporator / fans
- Expansion valve
- Temperature controller
- Supply air sensors
- Return air sensors
- Humidity sensor



The reefer temperature controller and expansion valve are not reflected in the above diagram.

Capabilities:

Set temperature range	:	+30°C to -35°C (+86°F to -31°F`)
Chilled commodities	:	Supply air sensor control +/- 0.25°C (+/- 0.4°F) accuracy within temperature set point
Frozen commodities	:	Return air sensor control Sub-zero °F maintained in all environments

Key features:

- Superior cooling capacity for quick achievement of set temperature
- High air flow capacity for high respiration cargoes
- Self-diagnostic units with latest microprocessor controller technology
- Hourly recording of transit temperatures and equipment performance, with the option to retrieve logged data at 15 or 30 minute intervals
- Archiving: Retain up to 2 years of historic data
- Monitoring of all four temperature sensors (supply and return air)
- Logging of humidity and ambient temperature readings
- Logging of pulp temperature recordings from the United States Department of Agriculture (USDA) 1, 2, 3 sensor probes
- Smart defrost technology
- Monitoring of any changes or events during transit
- Backup battery continues to record readings during port transshipment
- Snap freeze (evaporator fan delay) feature after defrosting to reduce heat input to the container (which is essential for the carriage of sensitive products)
- Quarantine certification compliant e.g. USDA or Australian Quarantine and Inspection Service (AQIS) requirements for cold treatment

Temperature digital display

The digital display will show the preset temperatures, container air temperatures, user codes and alarm codes. Temperatures can be checked whether the unit is on the ship, train or truck, or in a container yard.

The user-friendly controller 'scroll back' feature can also display the supply-air, return air and USDA temperature (if installed), and can be reviewed for the last 30 days – whether the unit is powered by a/c supply or backup battery – for easy temperature monitoring.

Carrier temperature digital display

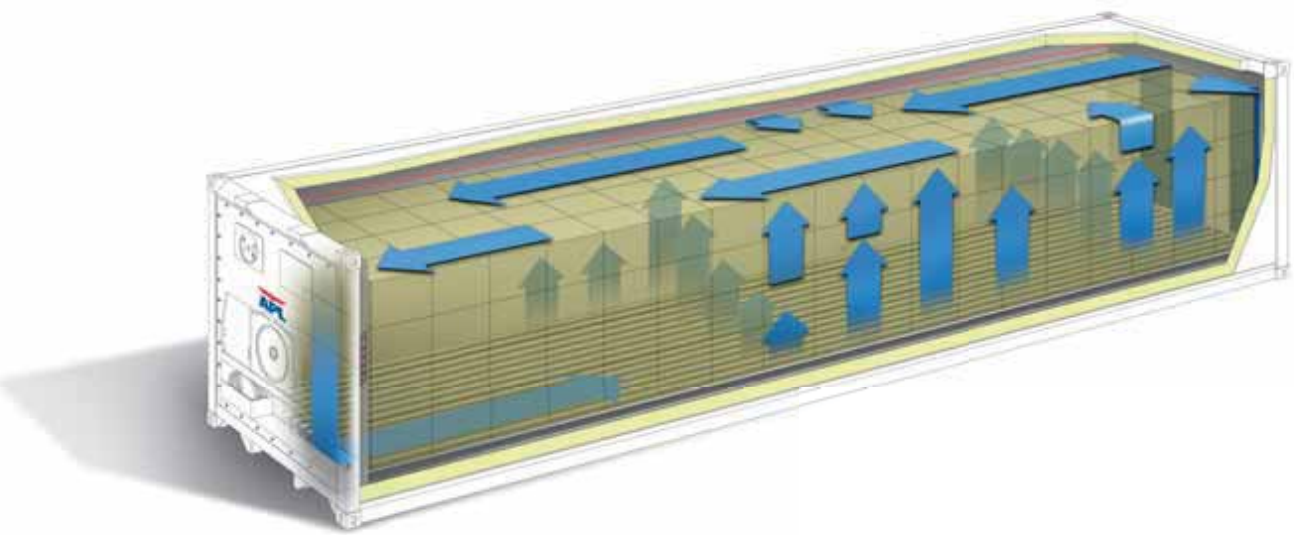
Daikin temperature digital display

Air-delivery system

All APL reefer containers are bottom-air delivery units, which means that air is consistently supplied from the bottom of the container through the T-bar floor. The advantage of APL's advanced reefer airflow system is that it delivers uniform and consistent air temperature across the entire floor and throughout the entire cargo area. The precise air temperature, in combination with optimal airflow, protects fresh products against moisture loss and shrinkage so they stay fresher longer and arrive in the best possible condition.

The bottom-air delivery method provides the most uniform and consistent temperature management.

- Refrigerated air is forced across the T-floor, under the cargo
- The cool air circulates through and around the cargo as it absorbs cargo heat
- Warm air is pulled by the evaporator fans at the top of the container. It is then directed through the evaporator coil, where it is cooled and discharged at the bottom (supply air)



Power sources and portable generators

APL refrigerated containers operate on external power sources. The power supply used is generally 3-phase (industrial) voltage supply of 380 volts/50 Hz or 440 volts/60Hz.

Containers may be plugged into a vessel's main power supply at sea or equipped with a power generator for land use.

Two types of portable generators are available:

- Underslung generator mounted beneath the chassis of a moving truck
- Clip-on generator attached to the "nose" of a container on a moving train or truck

A portable generator set or "genset" is required to continuously power the reefer container when it is off-loaded from the vessel because cargo is vulnerable to the ambient temperature if left without cooling or heating for extended periods of time. APL provides the industry's most powerful and reliable gensets for all modes of transport, protecting your cargo in all conditions.

The APL genset is capable of providing 15KW (18.75KVa) of continuous power output at ambient temperatures ranging from -40°C to +52°C (-40°F to +125°F) for long-haul transportation up to 7 days with a 125-gallon integrated fuel tank, subject to carriage temperature and ambient heat.

APL gensets emissions are compliant with local emission regulatory requirements e.g. California Air Resources Board (CARB).

APL REEFER SOLUTIONS

Quality assurance is the ultimate goal for APL's reefer solutions. APL has a full suite of reefer solutions, known as SMARTreefers, to achieve this goal. The word 'SMART' refers to APL's ability to deliver against our customers' S-M-A-R-T (Smart, Measurable, Attainable, Relevant and Time-based) objectives. SMARTreefers consist of the following technologies:

APL Reefer Solutions	SMARTreefers
Temperature Management	
Cold Treatment (CT)	SMARTcool
Atmostphere Management	
Controlled atmosphere (CA)	SMARTcare+
Regulated Atmosphere (RA)	SMARTcare
Humidity Management	
Dehumidification	SMARTair
Live Monitoring Tools	
Satellite Monitoring	SMARTemp

Temperature Management

The advanced temperature control system enables cargo to reach set point as quickly as possible without the supply air dropping below the set point. This is the key to preserving the freshness and quality of the cargo without causing any damage to temperature-sensitive loads.

We understand that dropping below the optimum set point, even by a small amount for a short period of time, may be very damaging to those cargoes that are sensitive to chilling or freezing injury. For instance, bananas that are located directly in front of the supply air in the container may be damaged if the air discharged falls below 13°C (55°F). This is why it is critical for reefer containers to quickly achieve optimum temperature without dropping below the set point.

Understanding the importance of precise temperature control for the most sensitive of cargoes, APL employs sophisticated control algorithms. These algorithms enable us to calculate the rate that supply-air temperature is dropping and throttle back on it as necessary (relying instead on higher airflow capacity) to ensure temperatures do not drop below the optimum set point.

These precise temperature control capabilities provide our customers with superior cargo protection and yield consistent, optimum cargo quality for all types of sensitive commodities.

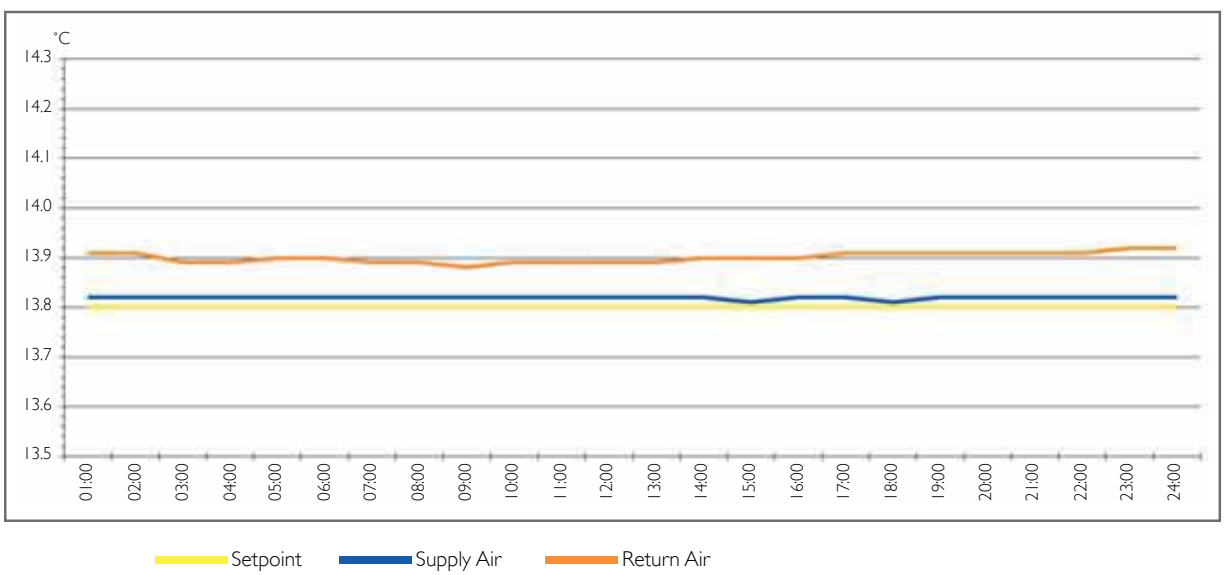
Chilled cargo

The standard temperature recording will show :

Bill of lading	:	987654321	Temperature unit	:	Centigrade
Origin	:	DVO	Date	:	20/Feb/2018
Destination	:	JEB	Set point	:	13.80
Origin date	:	01/Feb/2018	Container	:	APRU5828165
Discharge date	:	20/Feb/2018	Serial	:	04791094

Time	Supply Air	Return Air	PrRtTm	PrSuTm
01:00	13.82	13.91	13.91	13.80
02:00	13.82	13.91	13.91	13.80
03:00	13.82	13.89	13.89	13.80
04:00	13.82	13.89	13.89	13.80
05:00	13.82	13.90	13.90	13.80
06:00	13.82	13.90	13.90	13.80
07:00	13.82	13.89	13.89	13.80
08:00	13.82	13.89	13.89	13.80
09:00	13.82	13.88	13.88	13.80
10:00	13.82	13.89	13.89	13.80
11:00	13.82	13.89	13.89	13.80
12:00	13.82	13.89	13.89	13.80
13:00	13.82	13.89	13.89	13.80
14:00	13.82	13.90	13.90	13.80
15:00	13.81	13.90	13.90	13.80
16:00	13.82	13.90	13.90	13.80
17:00	13.82	13.91	13.91	13.80
18:00	13.81	13.91	13.91	13.80
19:00	13.82	13.91	13.91	13.80
20:00	13.82	13.91	13.91	13.80
21:00	13.82	13.91	13.91	13.80
22:00	13.82	13.91	13.91	13.80
23:00	13.82	13.92	13.92	13.80
24:00	13.82	13.92	13.92	13.80

PrRtTm: Primary Return Temperature
PrSuTm: Primary Supply Temperature



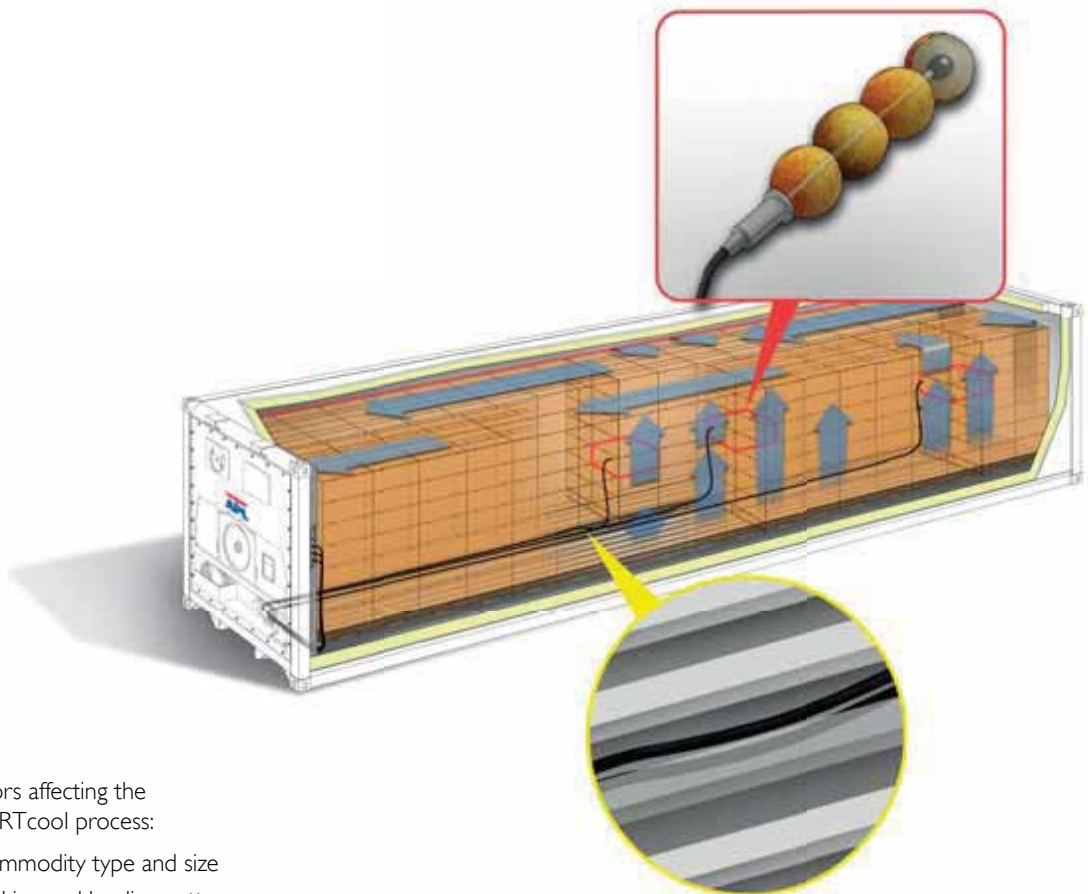
Note: Based on actual data downloaded from an APL reefer shipment.

SMARTcool – Cold Treatment (CT)

SMARTcool

SMARTcool is a special post-harvest process that exterminates fruit fl ies and their larvae, so shippers can meet local quarantine requirements. This process eliminates the need for fumigation and is done by maintaining a suffi ciently low temperature, uninterrupted over a period of time. SMARTcool can be carried out either in certified cold storage or during transportation (in-transit) with USDA cold-treatment-certified containers.

APL's SMARTcool process is an in-transit, post-harvest handling process. It is an environmentally-safe alternative to fumigation in order to eradicate pests. Cold treatment protocol differs based on regulations between importing and exporting countries, and also according to the commodity carried.



Factors affecting the SMARTcool process:

- Commodity type and size
- Packing and loading pattern
- Pre-cooling temperature and duration
- Ambient temperatures
- Container handling practice
- In-transit monitoring

When it comes to cold treatment, strict adherence to the appropriate procedures is crucial. If temperatures rise above the established requirement, the entire cold treatment process will fail and must be extended or re-initiated. All APL staff members are trained in the SMARTcool process to ensure that protocol is followed closely during the entire voyage.

Our in-transit SMARTcool process helps to:

- Effectively exterminate Mediterranean and tropical fruit flies and larvae
- Eliminate the need for fumigation using chemicals (e.g. methyl bromide) that are prohibited in many countries due to environmental concerns, thus ensuring better quality of fruit
- Allow perishables to get to market much faster and in optimum condition compared to land-based cold treatment in cold storage (because it is done before cargo loading or upon arrival)
- Enable products to command premium value and meet consumers' preference for non-fumigated produce

APL is well-placed to help you reap the benefits from the use of SMARTcool because:

- Our global experience in applying cold treatment has benefited customers shipping products such as kiwi, grapes, citrus, carambola, lychees, longans and more.
- We're highly reliable; we have an industry-leading success rate in meeting cold treatment protocols for various products globally.
- Our reefer professionals are meticulous in monitoring the temperatures continuously throughout transit and beyond; they'll also handle clearance at destination.
- APL's SMARTemp™ system can provide customers with live access to USDA temperatures, providing real-time data for review and instant alerts when pre-defined thresholds are met – and the ability to fine-tune requirements if necessary to meet the strict protocols.

Med fly protective screen for air vents

To protect perishables from potential infestation of fruit flies during transit, all APL reefer unit air ventilation systems are installed with med fly protective screens which prevent fruit flies from entering the container. This ensures your cargo arrives at its destination in optimum condition. The med fly protective screen also helps exporters meet the quarantine requirements of the various authorities in importing countries (e.g. USDA).

Atmosphere Management

Normal atmosphere consists of 78% nitrogen (N_2), 21% oxygen (O_2) and 0.03% carbon dioxide (CO_2). An unventilated container of fruit, with rapid respiration rates, can quickly change the atmosphere, reversing the normal levels of oxygen and carbon dioxide in less than 24 hours. That could be disastrous, because too little oxygen or too much carbon dioxide can lead to spoilage.

Atmospheric composition is important to fruit and vegetables because they 'breathe' or respire, consuming oxygen and producing carbon dioxide. Optimal atmospheric control can slow down the rate of produce respiration and delay ripening beyond what refrigeration alone can do.

Atmosphere management involves:

- Reducing oxygen
- Increasing or removing carbon dioxide
- Removing ethylene and other volatiles

Fresh air control

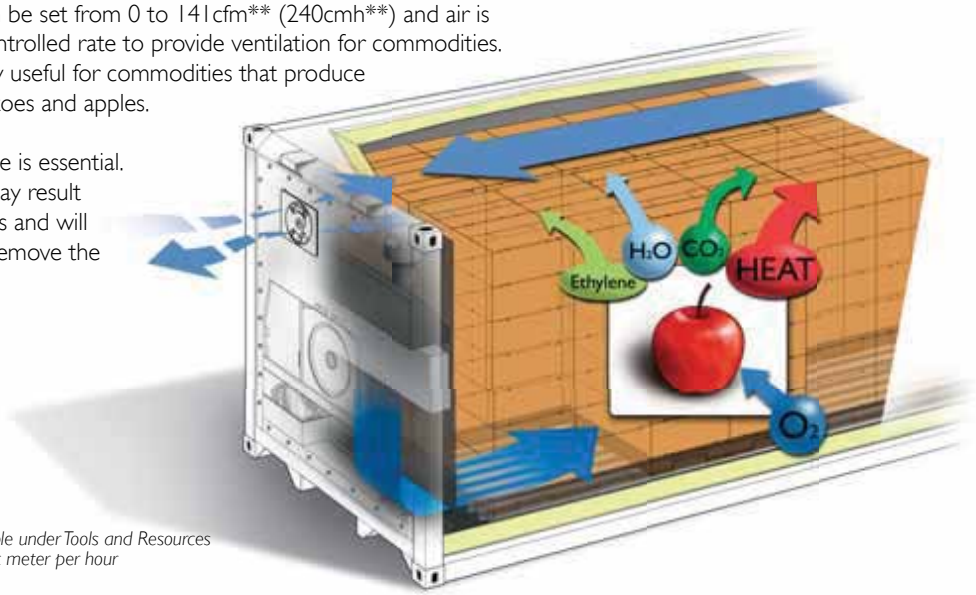
The amount of fresh air needed depends on the tolerance of the commodity to low levels of oxygen and high levels of carbon dioxide and ethylene, as well as the rate at which the commodity respires and produces ethylene.

Fresh air exchange:

- Protects some agricultural products by removing unwanted heat, ethylene, carbon dioxide and other gases produced by the cargo
- Helps prevent unwanted ripening and the accumulation of odors
- Ensures longer shelf life for many perishables

The fresh air exchange vent* can be set from 0 to 141cfm** (240cmh**) and air is drawn into the container at a controlled rate to provide ventilation for commodities. Fresh air ventilation is particularly useful for commodities that produce high levels of ethylene, like tomatoes and apples.

The fresh air ventilation technique is essential. However, excessive ventilation may result in freezing of the evaporator coils and will require additional defrosting to remove the build-up of ice.



** Please refer to the air vent conversion table under Tools and Resources*
*** cfm - cubic feet per minute; cmh – cubic meter per hour*

SMARTcare+

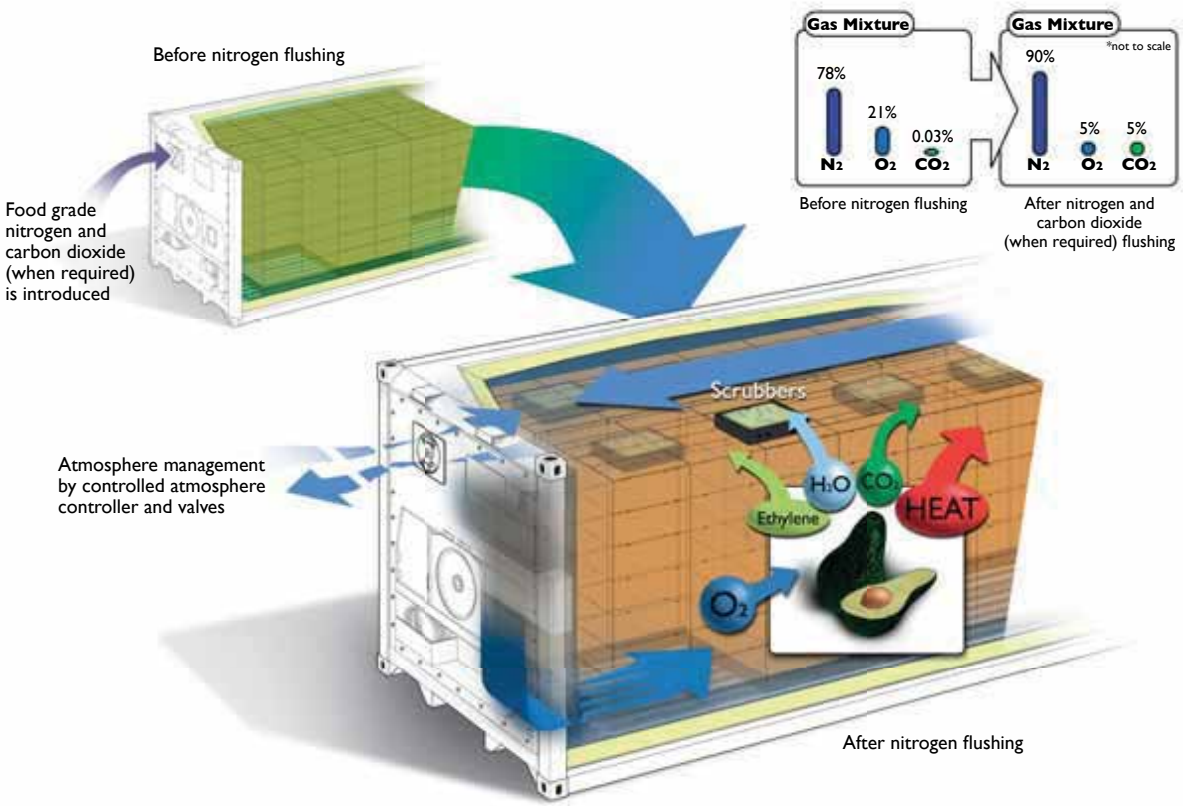
SMARTcare+ – Controlled Atmosphere (CA)

By working with the right partners, APL has the technology and knowledge to help you maintain the freshness of your produce. APL uses the 'One-Trip' active system to control the atmosphere inside a refrigerated container. APL has actively participated in the design and testing of the SMARTcare+ technology, which accurately monitors, adjusts and maintains the balance between oxygen, carbon dioxide and nitrogen to create the ideal atmosphere for extending the shelf life of fresh produce. By using the flexible and reliable 'One-Trip' active system, APL is able to provide SMARTcare+ services to any location in the world – so you can deliver produce that's always optimally fresh.

This is considered the most technologically advanced process available to precisely control atmospheric composition. It increases post-harvest life by up to three times more than other conventional methods.

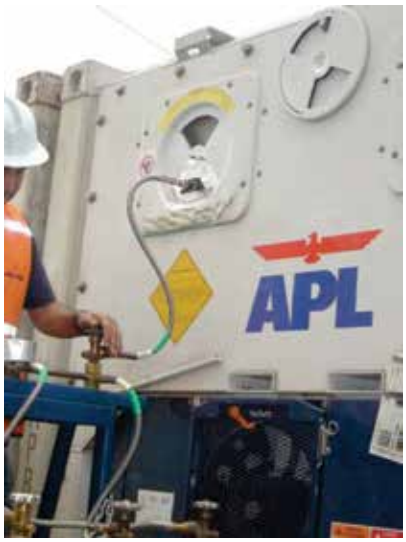
This process involves:

- Using technologically advanced computer systems to precisely monitor and actively control the atmosphere in the container and make adjustments throughout transit
- Tailoring the atmospheric conditions to provide the optimal environment for each commodity throughout the shipment's entire journey
- Recording changes in the atmospheric composition during a container's journey and providing data downloads or print-outs for quality-control purposes



The SMARTcare+ technology helps to:

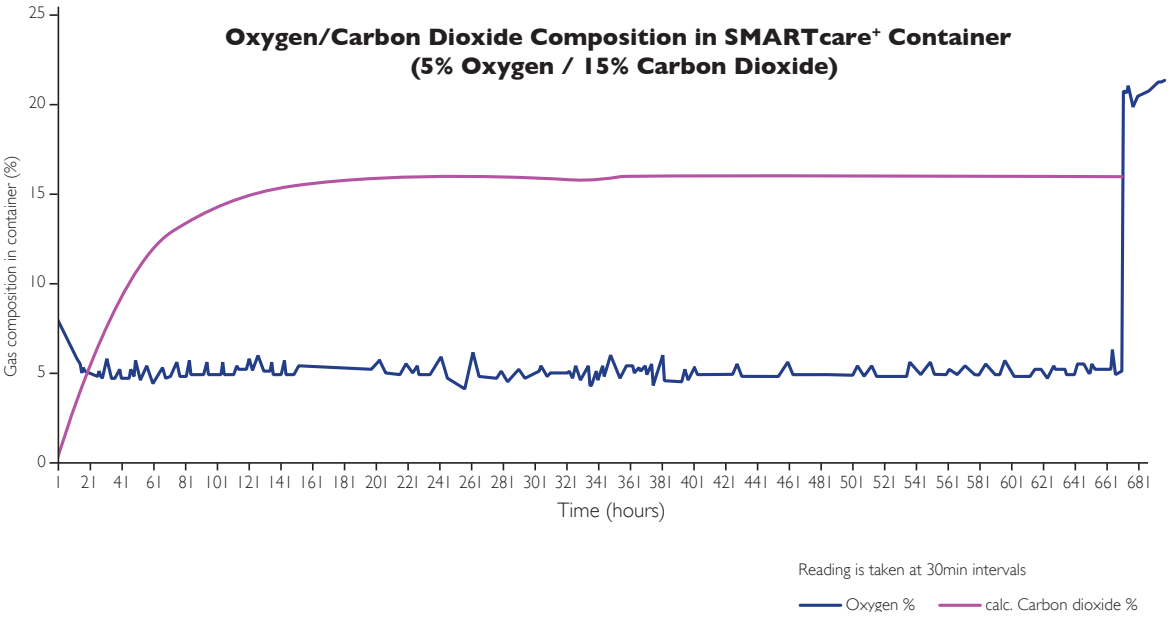
- Prolong shelf-life by retarding ripening and reducing respiration and ethylene production rates
- Slow down the deterioration of appearance, texture, flavor and nutritional quality of the produce
- Alleviate certain physiological disorders such as chilling injury
- Maintain freshness of the commodities, especially during longer voyages, making ocean transport a viable alternative to airfreight
- Provide insect control in some commodities to meet quarantine requirements of importing countries

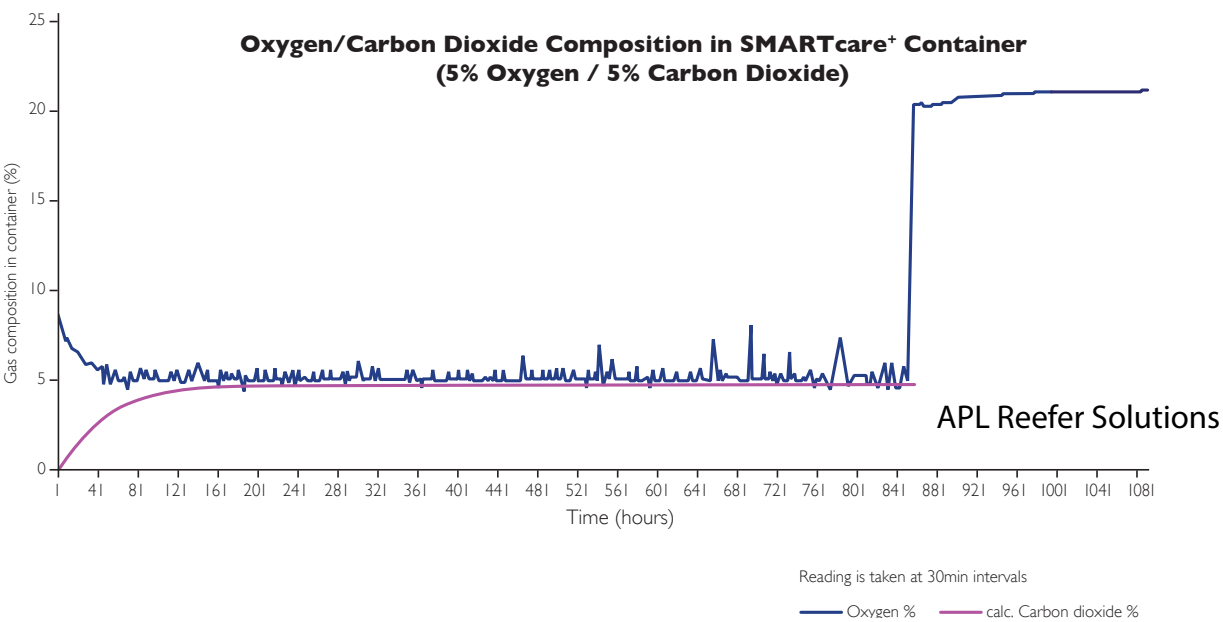


Common commodities shipped using the SMARTcare+ technology include avocados, asparagus, blueberries, stone fruit (e.g. plums, peaches and nectarines), apples, bananas, mangoes, kiwi, lychee and papayas.

Many products have successfully benefited from the use of SMARTcare+. The process helps to open up new markets by manipulating the ripening rate of fresh produce. APL is well-placed to help you reap the benefits from the use of SMARTcare+ because:

- We are actively involved in R&D and built the industry's first CA test chamber to enable customers to conduct trials; our test chamber has simulated optimal CA conditions for ocean transportation of different commodities, without the need to load a full container for testing
- Our reefer professionals are competent in advising you on post-harvest handling and packaging, doing everything from conducting trials for your shipment to monitoring its movement every step of the way
- We have a proven track record in using SMARTcare+ to help customers break into new, more distant markets. For example we were the first ocean carrier to ship asparagus from California to Japan





APL Reefer Solutions

*Graphs based on actual data output from APL reefer containers for SMARTcare+ shipments

Examples of longer product shelf-life with SMARTcare+

	Commodity	Normal Shipment	SMARTcare+ Shipment
Apples		2-6 Months	**6-12 Months**
Asparagus		1-3 Weeks	**2-4 Weeks**
Avocado		2-4 Weeks	**3-6 Weeks**
Blueberries		1-3 Weeks	**3-6 Weeks**
Broccoli		2-3 Weeks	**3-5 Weeks**
Cherries		2-3 Weeks	**3-4 Weeks**

	Commodity	Normal Shipment	SMARTcare+ Shipment
Grapes		1-3 Weeks	**1-7 Months**
Papayas		2-3 Weeks	**3-5 Weeks**
Mangoes		2-3 Weeks	**3-5 Weeks**
Nectarines		3-4 Weeks	**4-9 Weeks**
Peaches		3-4 Weeks	**4-8 Weeks**
Plums		4-6 Weeks	**6-9 Weeks**

Through years of working with leading university researchers to develop the latest reefer technology and post-harvest handling processes, APL has proven just how committed it is to providing the specialized care your products need so that they reach markets in prime condition and command premium value.

SMARTcare

SMARTcare – Regulated Atmosphere (RA)

Commodity generated atmosphere

Some atmospheric modification systems rely on product respiration to achieve the gases internally. Typically:

- Using polyethylene film to regulate the commodity generated atmosphere within the package
- By manipulating shipping container vents in accordance with cargo respiration

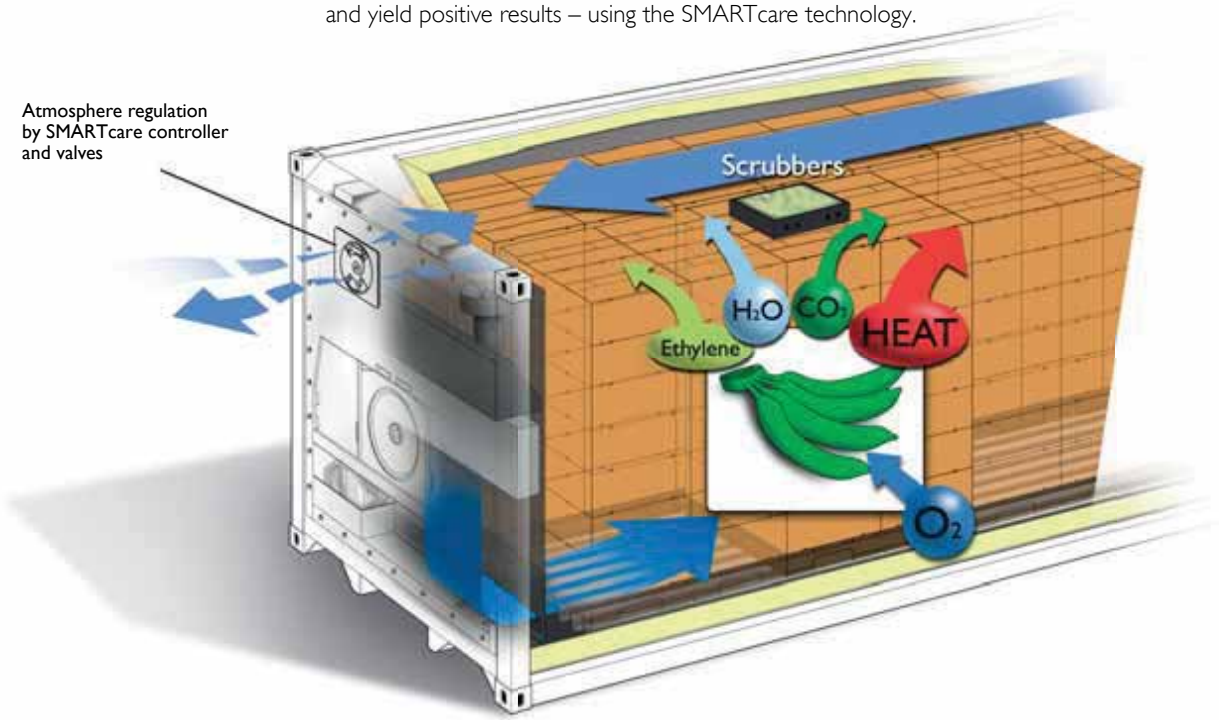
APL's SMARTcare technology is recommended for commodities that require atmosphere management but do not need a full SMARTcare+ (CA) application.

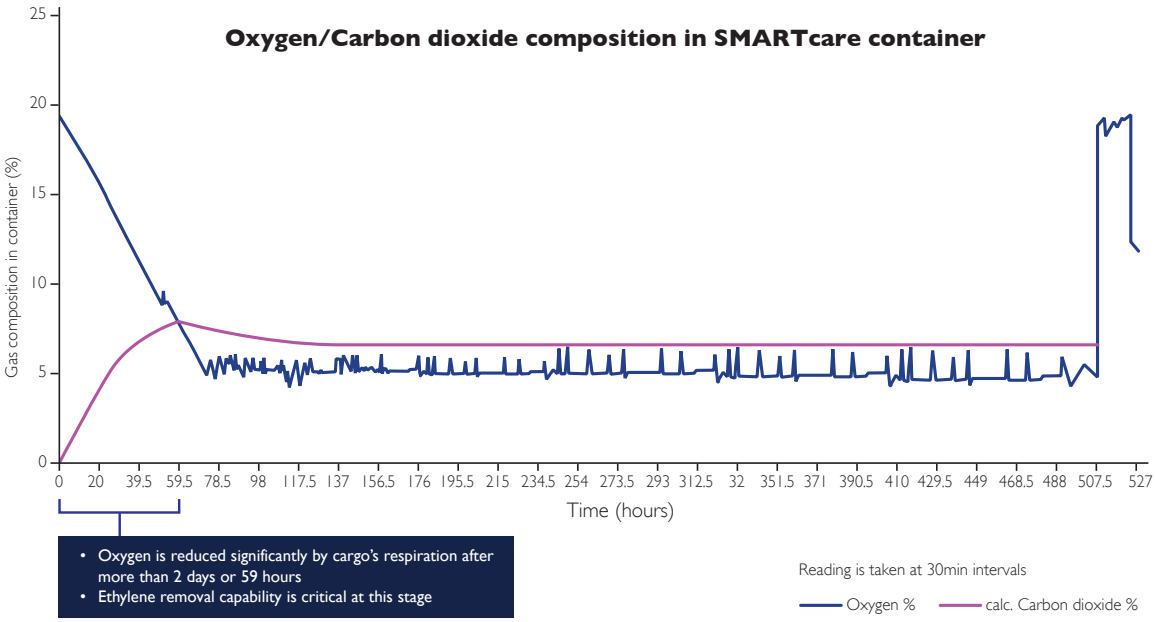
How it works:

- Utilizes cargo respiration to achieve oxygen set point
- Maintains atmosphere set point once target oxygen level is reached
- Maintains carbon dioxide by using controlled absorption rate scrubbers with permeable membrane
- Removes ethylene

Like any atmosphere control system, our SMARTcare technology is an enhancement to good temperature control – not a replacement for it. SMARTcare provides more precise atmosphere management than other commodity-generated atmosphere systems (such as modified atmosphere bags or auto vent systems) and is a cost-effective alternative to using SMARTcare+ for container atmosphere management. Bananas and lettuce are examples of commodities which can be transported across the Pacific – and yield positive results – using the SMARTcare technology.

Atmosphere regulation by SMARTcare controller and valves




Oxygen/Carbon dioxide composition in SMARTcare container
Gas composition in container (%)
25
20
15
10
5
0
0 20 39.5 59.5 78.5 98 117.5 137 156.5 176 195.5 215 234.5 254 273.5 293 312.5 32 351.5 371 390.5 410 429.5 449 468.5 488 507.5 527
Time (hours)
• Oxygen is reduced significantly by cargo's respiration after more than 2 days or 59 hours
• Ethylene removal capability is critical at this stage
Reading is taken at 30min intervals
Oxygen %
calc. Carbon dioxide %

SMARTair – Humidity Management

The humidity level has a direct influence on the quality of your produce – especially as it pertains to shelf life.

Low humidity levels cause:
- Dehydration of produce
- Weight loss
- Negative changes in produce appearance

High humidity levels cause:
- Growth of mold and bacteria
- Fungal disorders

Relative humidity in the air that circulates in a reefer container depends on the following key factors:
- Rate of fresh air ventilation
- Relative humidity of fresh air entering into the container
- Temperature of the evaporator coil relative to the dew point of the air in the container
- Vapor pressure deficit, which will influence the rate of moisture transfer between the air and commodity
- Carriage and produce temperature
- Packaging
- Type of commodity (respiration rate)

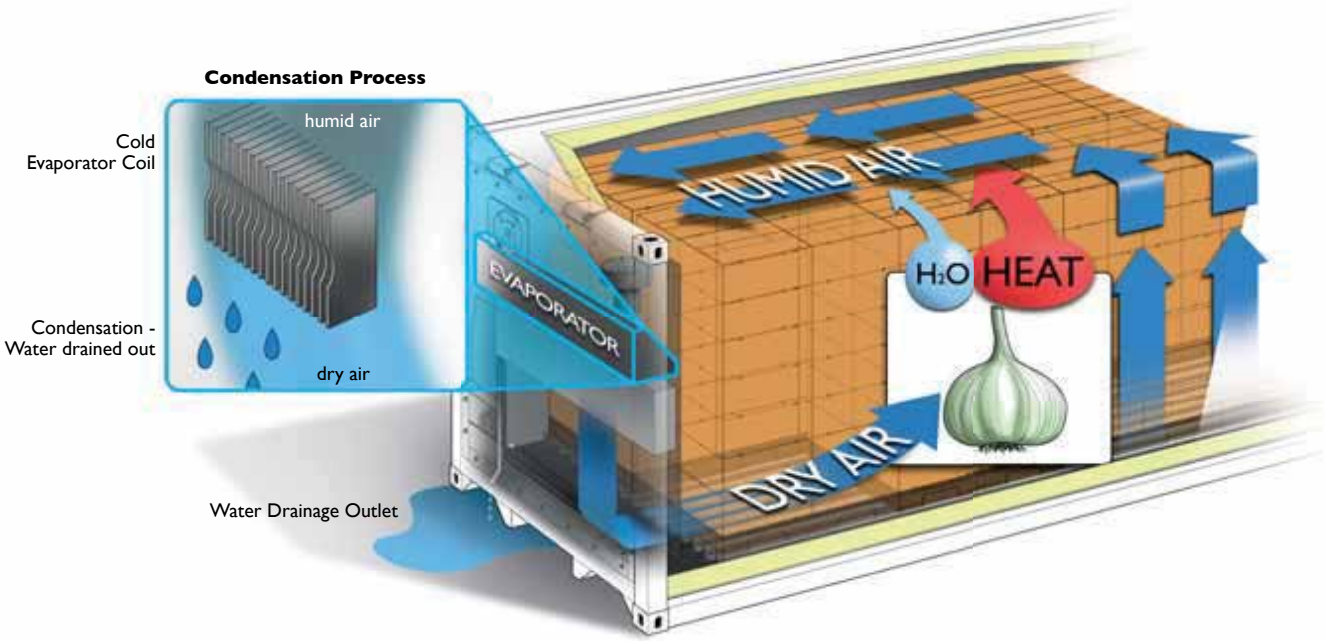
Humidity control

In reefer containers, humidity can be influenced in the following ways:
1. Top-icing for products that are not susceptible to freezing or chilling injury, e.g. broccoli
2. Applying perforated film packaging
3. Using moisture pads (for items such as asparagus)
4. Maintaining surface wax (for items such as apples)

It is critical to understand that cargo needs to be pre-cooled to its optimal temperatures, because there will be a rapid loss of humidity if cargoes are warm-loaded. Large temperature differences between the cooling units and cargo will lead to condensation on the cooling coiling, which dries the air and causes evaporation from the produce; ultimately resulting in water loss.

Dehumidification

Dehumidification is a process that lowers humidity within the container to ensure dry packing, prevent rotting and reduce the incidence of fungal development. It is especially vital to carry out dehumidification for containers carrying commodities such as pharmaceutical products, electronic components, photographic film, onions, ginger and garlic.



Most of APL's reefer equipment comes equipped with dehumidification systems where relative humidity can be set between 60% and 95% and can be controlled according to cargo requirements.

Bulb mode

This feature is used mainly for the transportation of flower bulbs. It is an extension of dehumidification mode and upon activation, the user can select:

- Evaporator fan speed (low, high or alternate)
- Defrost termination sensor setting
- Lower humidity levels

Bulb mode, utilized mainly for transportation of flower bulbs, provides exporters with better control of the adjustable features to accommodate the need for optimal storage conditions, facilitating stringent temperature, ventilation and humidity requirements for a large variety of bulbs. All APL containers are ATO certified by research institution Agrotechnology and Food Innovations (AFI).

Commodity handling table

Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
FRESH VEGETABLES AND MELONS											
Amaranth Leaves	10 ~ 14	34	1.1	45	77	none	32 ~ 34	0 ~ 1.1			
Anise	14 ~ 21	32 ~ 36	0 ~ 2.2	closed	closed	none	32 ~ 34	0 ~ 1.1			
Aravi - Yams	50 ~ 115	56 ~ 60	13.3 ~ 15.6	closed	closed	none/slight	56 ~ 60	13.3 ~ 15.6	30	-1.1	
Artichokes, Globe	14 ~ 21	32 ~ 33	0 ~ 0.6	45	77	good	32 ~ 41	0 ~ 5	29.9	-1.2	
Artichokes, Jerusalem	100 ~ 150	33 ~ 34	0.6 ~ 1.1	15	26	none	30 ~ 41	-1.1 ~ 5	27.5	-2.5	
Asparagus, Green	14 ~ 21	33 ~ 36	0.6 ~ 2.2	45	77	good	35 ~ 41	17 ~ 5	30.9	-0.6	Asparagus is sensitive to chilling injury after 10 days at 32°F.
Bean Sprouts - Mung Beans	7 ~ 9	32	0	45	77	none	32 ~ 44	0 ~ 6.7			
Beans, Lima, Shelled	7 ~ 10	37 ~ 39	2.8 ~ 3.9	45	77	none	37 ~ 45	2.8 ~ 7.2	31	-0.6	
Beans, Lima, Unshelled	7 ~ 10	41 ~ 43	5 ~ 6.1	45	77	none	37 ~ 45	2.8 ~ 7.2	31	-0.6	
Beans, Snap or Green	10 ~ 14	38 ~ 40	3.3 ~ 4.4	30	50	fair	36 ~ 42	2.2 ~ 5.5	30.7	-0.7	
Beans, Winged	28	50	10	closed	closed	none	50 ~ 60	10 ~ 15.6			
Beets, Bunch	10 ~ 14	34	1.1	15	26	slight	32 ~ 41	0 ~ 5	31.3	-0.4	
Beets, Root	90 ~ 150	34	1.1	closed	closed	slight	31 ~ 41	-0.6 ~ 5	30.3	-0.9	
Belgian Endive - Witloof Chicory	7 ~ 14	34 ~ 36	1.1 ~ 2.2	60	102	good	32 ~ 41	0 ~ 5			
Bok Choy	30 ~ 60	32 ~ 34	0 ~ 1.1	30	50	good	31 ~ 41	-0.6 ~ 5			
Broccoli	7 ~ 14	32 ~ 33	0 ~ 0.6	17	30	good	31 ~ 41	-0.6 ~ 5	30.9	-0.6	Avoid setting temp at 31°F or below.
Brussels Sprouts	21 ~ 35	32 ~ 33	0 ~ 0.6	30	50	good	31 ~ 41	-0.6 ~ 5	30.5	-0.9	
Cabbage, Chinese - Napa Cabbage	30 ~ 60	32 ~ 36	0 ~ 2.2	15	26	good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Cabbage, Green (Early)	21 ~ 42	32 ~ 36	0 ~ 2.2	15	26	good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Cabbage, Green (Late)	90 ~ 180	32 ~ 36	0 ~ 2.2	15	26	good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Cabbage, Red (Early)	21 ~ 42	32 ~ 36	0 ~ 2.2	15	26	good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Cabbage, Red (Late)	90 ~ 180	32-36	0 ~ 2.2	15	26	good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Cactus Steams - Nopales	14 ~ 21	41 ~ 50	5 ~ 10	closed	closed	none	36 ~ 55	2.2 ~12.8			Discoloration can occur due to chilling injury if stored longer than 3 weeks at 41°F.
Calabaza	60 ~ 90	50	10	15	26	none	50 ~ 55	10 ~12.8			
Cantaloupe	12 ~ 21	37 ~ 41	2.8 ~ 5	30	50	fair	36 ~ 50	2.2 ~10	29.9	-1.2	Avoid setting temp at 35°F or below.
Carrots, Topped	28 ~ 180	32 ~ 41	0 ~ 5	15	26	slight	30 ~ 44	-1.1 ~ 6.7	29.5	-1.4	
Cauliflower	21	33	0.6	30	50	fair	31 ~ 41	-0.6 ~ 5	30.6	-0.8	Transit time more than 21 days not recommended.
Celeriac	180 ~ 240	33 ~ 34	0.6 ~ 1.1	15	26	slight	31 ~ 41	-0.6 ~ 5	30.3	-0.9	
Celery	35 ~ 49	33	0.6	15	26	fair	32 ~ 41	0 ~ 5	31.1	-0.5	Freezing injury will be initiated at 31.1°F.
Chard	10 ~ 14	34	1.1	45	77	none	32 ~ 41	0 ~ 5	31.9	-0.1	
Chayote	28 ~ 42	45	7.2	closed	closed	none	32 ~ 55	0 ~ 12.8	31	-0.6	
Chicory	14 ~ 28	33 ~ 34	0.6 ~ 1.1	45	77	none	31 ~ 41	-0.6 ~ 5			
Chives	14 ~ 21	33 ~ 34	0.6 ~ 1.1	45	77	none	32 ~ 41	0 ~ 5			
Collards	10 ~ 14	33 ~ 34	0.6 ~ 1.1	45	77	none	31 ~ 41	-0.6 ~ 5	30.6	-0.8	
Corn, Sweet	7	33 ~ 34	0.6 ~ 1.1	45	77	good	31 ~ 41	-0.6 ~ 5	30.9	-0.6	Due to high rate of respiration & conversion of sugars to starch, transit time more than 7 days not recommended. Freezing injury will be initiated at 31.1°F.
Cucumbers	10 ~ 14	50 ~ 55	10 ~ 12.7	15	26	fair	45 ~ 60	7.2 ~ 15.6	30.1	-1.1	Avoid setting temp at 50°F or below. Transit time more than 14 days not recommended.
Daikon - Black Radish	60 ~ 120	34	1.1	15	26	none	31 ~ 41	-0.6 ~ 5			

Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
Dasheen - Taro & Eddo	42 ~ 140	50	10	closed	closed	none/slight	45 ~ 55	7.2 ~ 12.8			
Eggplant	10 ~ 14	50-54	10 ~ 12.2	15	26	fair	45 ~ 65	7.2 ~ 18.3	30.6	-0.8	Avoid setting temp at 49°F or below. Transit time more than 14 days not recommended.
Endive - Escarole	14 ~ 28	34	1.1	30	50	good	32 ~ 41	0 ~ 5	31.9	-0.1	
Garlic	90 ~ 210	31	0.6	15	26	good	31 ~ 46	-0.6 ~ 7.8	Below 30	-1.1	R/H 60-70% preferred. Garlic cloves must be properly cured prior to shipping. Avoid temp range 41-65°F.
Ginger	90 ~ 180	56	13.3	15	26	none/slight	50 ~ 66	10 ~ 18.9			R/H 65% preferred. Ginger roots must be cured properly prior to shipping. Avoid temp below 55°F.
Greens, Leafy	10 ~ 14	32-33	0 ~ 0.6	30	50	none	32 ~ 41	0 ~ 5	31.7	-0.2	
Horseradish	300 ~ 351	34	1.1	closed	closed	none/slight	30 ~ 39	-1.1 ~ 3.9	28.7	-1.8	
Jicama	30 ~ 60	55	12.7	closed	closed	none	55 ~ 65	12.8 ~ 18.3			
Kale	10 ~ 14	33	0.6	30	50	none	32 ~ 41	0 ~ 5	31.1	-0.5	
Kiwanus	180	50	10	45	77	none	50 ~ 60	10 ~ 15.6			
Kohirabi, Topped	60 ~ 90	33 ~ 34	0.6 ~ 1.1	15	26	none/slight	31 ~ 41	-0.6 ~ 5	30.2	-1.0	
Leeks, Green	60 ~ 90	32	0	30	50	good	32 ~ 41	0 ~ 5	30.7	-0.7	
Lettuce, Crisphead or Iceberg	12 ~ 14	33	0.6	15	26	good	32 ~ 41	0 ~ 5	31.7	-0.2	Freezing damage can occur at 31.7°F or below. Extremely sensitive to ethylene.
Lettuce, Romaine or Cos	14 ~ 21	33	0.6	15	26	good	32 ~ 41	0 ~ 5	31.7	-0.2	Same as iceberg/crisphead lettuce. Avoid using propane fork-lift for stuffing.
Malanga - Cocoyam, Yautia	42	50	10	closed	closed	none/slight	55 ~ 66	12.8 ~ 18.9			
Manioc - Cassava, Yuca	21 ~ 35	41	5	closed	closed	none/slight	38 ~ 45	3.3 ~ 7.2			
Melons, Bitter	14 ~ 21	54 ~ 55	12.2 ~ 12.8	closed	closed	none	54 ~ 60	12.2 ~ 15.6			
Melons, Casaba	21 ~ 28	50	10	45	77	fair	50 ~ 65	10 ~ 18.3	30.1	-1.1	
Melons, Crenshaw	14 ~ 21	50	10	45	77	good	45 ~ 60	7.2 ~ 15.6	30.1	-1.1	
Melons, Honeydew	21 ~ 28	45	7.2	15	26	good	41 ~ 60	5 ~ 15.6	30.9	-0.6	
Melons, Persian	14 ~ 21	50	10	45	77	good	45 ~ 65	7.2 ~ 18.3	30.6	-0.8	
Mushrooms	12 ~ 17	33 ~ 34	0.6 ~ 1.1	45	77	fair	31 ~ 41	-0.6 ~ 5	30.4	-0.9	Freezing injury will likely occur at temp 30.9°F. As mushrooms will continue to develop after harvest, remove field heat quickly.
Okra	7 ~ 14	45 ~ 50	7.2 ~ 10	15	26	fair	45 ~ 55	7.2 ~ 12.8	28.7	-1.8	
Onions, Dry	30 ~ 270	33 ~ 34	0.6 ~ 1.1	30	50	none	31 ~ 41	-0.6 ~ 5	30.6	-0.8	Avoid temp range 41-68°F (will sprout and decay rapidly).
Onions, Green	21 ~ 28	33	0.6	30	50	good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Parsley	30 ~ 60	33 ~ 34	0.6 ~ 1.1	30	50	good	31 ~ 41	-0.6 ~ 5	30	-1.1	
Parsnips	120 ~ 150	33 ~ 34	0.6 ~ 1.1	closed	closed	none/slight	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Peas, Snow and Snap Pod	7 ~ 14	33 ~ 34	0.6 ~ 1.1	30	50	good	31 ~ 41	-0.6 ~ 5	30.9	-0.6	
Peppers, Bell - Sweet Peppers	21 ~ 35	41 ~ 45	5 ~ 7.2	15	26	fair	41 ~ 55	5 ~ 12.8	30.7	-0.7	Avoid setting temp 41°F or below. Chilling injury will occur if stored at 41°F for longer than 2 weeks.
Peppers, Hot Chilli	14 ~ 21	50	10	15	26	slight	45 ~ 55	7.2 ~ 12.8	30.7	-0.7	
Potatoes, Early	21 ~ 35	55	12.8	15	26	none/slight	50 ~ 70	10 ~ 21.1	30.5	-0.8	Storing immature potatoes below 55°F may cause the accumulation of reducing sugars, leading to excessive browning during frying/chipping. However, it will allow extended storage life.
Potatoes, Late	150	45	7.2	15	26	none/slight	36 ~ 50	2.2 ~ 10	30.5	-0.8	Avoid exposure to bright light which will induce greening.
Potatoes, Sweet - Boniato	90 ~ 180	56	13.3	closed	closed	none/slight	56 ~ 66	13.3 ~ 18.9	29.7	-1.3	
Pumpkins & Winter Squash	60 ~ 180	55 ~ 59	12.8 ~ 15	15	26	none/slight	50 ~ 70	10 ~ 21.1	30.5	-0.8	Pumpkins and winter squash are very chilling sensitive when stored below 50°F.
Radicchio	14 ~ 21	34	1.1	45	77	none	32 ~ 41	0 ~ 5			
Radishes, Red (topped)	21 ~ 28	33	0.6	15	26	none/slight	31 ~ 41	-0.6 ~ 5	30.7	-0.7	
Radishes, Daikon-type Radish	90 ~ 120	33	0.6	15	26	none/slight	31 ~ 41	-0.6 ~ 5	30.7	-0.7	
Rhubarb	14 ~ 21	34	1.1	15	26	none	31 ~ 41	-0.6 ~ 5	30.3	-0.9	
Rutabagas	60 ~ 120	33 ~ 34	0.6 ~ 1.1	15	26	none/slight	31 ~ 41	-0.6 ~ 5	30.1	-1.1	

Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
Salsify	60 ~ 120	33 ~ 34	0.6 ~ 1.1	15	26	none/slight	31 ~ 41	-0.6 ~ 5	30.1	-1.1	
Scorzonera - Black Salsify	180	33 ~ 34	0.6 ~ 1.1	15	26	good	32 ~ 41	0 ~ 5			
Shallots	21 ~ 28	32	0	30	50	good	31 ~ 41	-0.6 ~ 5			
Spinach	10 ~ 14	33 ~ 34	0.6 ~ 1.1	45	77	fair	32 ~ 41	0 ~ 5	31.5	-0.3	Freezing injury will be initiated at 31.5°F.
Summer Squash	10 ~ 14	41 ~ 50	5-10	15	26	none/slight	41 ~ 55	5 ~ 12.8	31.1	-0.5	Summer squash are chilling sensitive at temp below 41°F.
Swiss Chard	30 ~ 60	33 ~ 34	0.6 ~ 1.1	30	50	good	31 ~ 34	-0.6 ~ 1.1			
Tomato, Mature-green	14 ~ 21	55 ~ 60	12.8 ~ 15.5	15	26	good	50 ~ 65	10 ~ 18.3	30	-1.1	Tomatoes are chilling sensitive at temp below 50°F.
Tomato, Light Red	10 ~ 14	50 ~ 55	10 ~ 12.8	15	26	good	50 ~ 65	10 ~ 18.3	30	-1.1	Tomatoes are chilling sensitive at temp below 50°F.
Water Chestnuts	100 ~ 128	33 ~ 34	0.6 ~ 1.1	15	26	none	32 ~ 50	0 ~ 10			
Watercress	14 ~ 21	33	0.6	45	77	none	32 ~ 41	0 ~ 5	31.5	-0.3	
Watermelons, Seeded or Seedless	14 ~ 21	50 ~ 59	10 ~ 15	15	26	none/slight	50 ~ 60	10 ~ 18.3	30.9	-0.6	Watermelons are prone to chilling injury when stored at 45°F or below.
FRESH FRUITS											
Acerola- Barbados Cherry	50 ~ 58	34	1.1	closed	closed	none	32 ~ 40	0 ~ 4.4			
Apples, Fuji, Gala, Golden & Red Delicious	90 ~ 240	32	0	17	30	excellent	30 ~ 44	-1.1 ~ 6.7	29	-1.7	Storage in dark environment plus low O_2 (1-3%) & high CO_2 (1.5-3%) will increase post-harvest life expectancy up to 10 months.
Apples, Granny Smith	90 ~ 240	33	0.6	17	30	excellent	30 ~ 44	-1.1 ~ 6.7	29.3	-1.5	Some reports indicate that chilling injury can occur at temp 32°F.
Apples, Chilling Sensitive	40 ~ 45	40	4.4	17	30		36 ~ 50	2.2 ~ 10	29.3	-1.5	
Apricots	7 ~ 14	33	0.6	30	50	good	31 ~ 46	-0.6 ~ 7.8	30.5	-0.8	Avoid temp range 36-46°F.
Atemoya	28 ~ 42	55	12.8	closed	closed	none	55 ~ 60	12.8 ~15.6			
Avocados, Mature-green	21 ~ 28	41 ~ 55	5 ~ 12.7	30	50		40 ~ 60	4.4 ~ 15.6	31.5	-0.3	Use of CA recommended for longer transit.
Avocados, Ripe Avocados	14 ~ 21	36 ~ 40	2.2 ~ 4.4	30	50	good	40 ~ 60	4.4 ~ 15.6	31.5	-0.3	Use of CA recommended for longer transit.
Babaco	7 ~ 21	45	7.2	closed	closed	none	45 ~ 50	7.2 ~ 10			
Bananas	7 ~ 28	56 ~ 57	13.3 ~ 13.9	15	26	excellent	57 ~ 65	13.9 ~ 18.3	30.6	-0.8	Avoid setting temp below at 55°F. Best temp for bananas is at 55.76°F.
Berries, Blackberries	2 ~ 3	33	0.6	15	26	very good	31 ~ 41	-0.6 ~ 5	30.6	-0.8	
Berries, Blueberries	7 ~ 14	33	0.6	15	26	very good	31 ~ 41	-0.6 ~ 5	29.7	-1.3	
Berries, Cranberries	60 ~ 120	37 ~ 40	2.8 ~ 4.4	15	26	slight	34 ~ 45	1.1 ~ 7.2	30.4	-0.9	
Berries, Currants	7 ~ 14	33	0.6	15	26	none	31 ~ 41	-0.6 ~ 5	30.2	-1.0	
Berries, Dewberries	2 ~ 3	33	0.6	15	26	none	31 ~ 41	-0.6 ~ 5	29.7	-1.3	
Berries, Elderberries	5 ~ 14	33	0.6	15	26	none	31 ~ 41	-0.6 ~ 5	30	-1.1	
Berries, Gooseberries	14 ~ 28	33	0.6	15	26	none	31 ~ 41	-0.6 ~ 5	30	-1.1	
Berries, Loganberries	2 ~ 3	33	0.6	15	26	none	31 ~ 41	-0.6 ~ 5	29.7	-1.3	
Berries, Raspberries	2 ~ 3	34	1.1	15	26	very good	31 ~ 41	-0.6 ~ 5	30.4	-0.9	
Breadfruit	14 ~ 40	55 ~ 57	12.8 ~ 13.8	45	77	good	54 ~ 65	12.2 ~ 18.3			
Cactus Pear - Prickly Pears	14 ~ 35	43 ~ 46	6.1 ~ 7.8	15	26	good	41 ~ 50	5 ~ 10			
Calamondin	14	48 ~ 50	8.9 ~ 10	closed	closed	none	48 ~ 55	8.9 ~ 12.8			
Canistel - Egg Fruit	21	55	12.8	closed	closed	none	55 ~ 60	12.8 ~ 15.5			
Cherries, Sour	3 ~ 7	32	0	15	26	very good	29 ~ 44	-1.7 ~ 6.7	29	-1.7	
Cherries, Sweet	14 ~ 21	31	-0.6	15	26	very good	29 ~ 44	-1.7 ~ 6.7	28.8	-1.8	
Clementines	14 ~ 21	40	4.4	45	77	none	38 ~ 45	3.3 ~ 7.2			
Coconuts	30 ~ 60	32 ~ 34	0 ~ 1.1	closed	closed	none	31 ~ 46	-0.6 ~ 7.8	30.4	-0.9	
Dates	180 ~ 365	32	0	15	26	none	32 ~ 46	0 ~ 7.8	3.7	-15.7	Preferred R/H level at 70-75%.
Dragon Fruits	28 ~ 35	45	7.2	15	26	no published information	45 ~ 55	7.2 ~ 12.8	N/A		
Dried Fruit & Nuts	6 months and up	32 ~ 50	0 ~ 10	closed	closed	excellent	32 ~ 70	0 ~ 21.1			The lower the moisture, the longer the post-harvest life.

Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
Durian, Ripe	7 ~ 14	55 ~ 59	12.8 ~ 15	30	50	good	39 ~ 50	3.9 ~ 10			Cultivars vary in their chilling sensitivity. Can be damaged by storage at 41°F for 1 week and 50°F for 2 weeks.
Durian, Mature Unripe	21 ~ 35	55 ~ 59	12.8 ~ 15	30	50	good	39 ~ 50	3.9 ~ 10			Cultivars vary in their chilling sensitivity. Can be damaged by storage at 41°F for 1 week and 50°F for 2 weeks.
Feijoa	28 ~ 35	41	5	closed	closed	none	41 ~ 50	5 ~ 10			
Figs	7 ~ 14	32	0	15	26	good	28 ~ 44	-2.2 ~ 6.7	27.6	-2.4	California-grown "Black Mission" & "Calimyrna" at CA combination of 5-10% O_2 and 15-20% CO_2.
Grapefruit, Arizona/ California/Dry Areas	28 ~ 42	58	14.4	15	26	fair	48 ~ 60	8.9 ~ 15.6	30	-1.1	
Grapefruit, Florida/Humid Areas	28 ~ 42	48 ~ 60	8.9 ~ 15.6	15	26	fair	48 ~ 60	8.9 ~ 15.6	30	-1.1	
Grapes, Table	56 ~ 180	31	-0.6	9 or close	15 or close	good	30 ~ 42	-1.1 ~ 5.6	28.1	-2.2	
Guavas	14 ~ 21	46 ~ 50	7.8 ~ 10	30	50	slight	41 ~ 55	5 ~ 12.8			
Jackfruit	14 ~ 21	56	13.3	45	77	no published information	56 ~ 80	13.3 ~ 26.7			Avoid setting temp below 54°F (chilling injury).
Jujubes	60 ~ 90	38 ~ 50	3.3 ~ 10	30	50	no published information	36 ~ 55	2.2 ~ 12.8			Fresh jujubes are susceptible to chilling injury if kept below 38°F.
Kiwifruit - Chinese Gooseberry	90 ~ 150	33	0.6	15	26	excellent	31 ~ 39	-0.6 ~ 3.9	29.3	-1.5	Freezing damage can occur on early picked kiwi fruit when at 32°F or below.
Kumquats	14 ~ 28	39	3.9	closed	closed	none	34 ~ 45	1.1 ~ 7.2			
Langsat	10 ~ 15	52	11.1	closed	closed	no published information	52 ~ 60	11.1 ~ 15.6			
Lemons	30 ~ 180	54 ~ 57	12.2 ~ 13.9	15	26	good	45 ~ 60	7.2 ~ 15.6	29.4	-1.4	
Limes	42 ~ 56	50 ~ 55	10 ~ 12.8	15	26	use of CA is limited					
Longan	14 ~ 28	36 ~ 41	2.2 ~ 5	30	50	good	35 ~ 45	1.7 ~ 7.2			
Loquat	14 ~ 28	33	0.6	15	26	no published information	32 ~ 41	0 ~ 5			
Lychee	21 ~ 35	35 ~ 50	1.7 ~ 10	15	26	good	34 ~ 50	1.1 ~ 10			Storage at 34°F or below for longer than 12 days will result in chilling injury.
Mangoes, Partially-ripe & Ripe	14 ~ 21	50	10	30	50	good	45 ~ 55	7.2 ~ 12.8	30.4	-0.9	
Mangoes, Mature-green	21 ~ 28	55	12.8	30	50	good	50 ~ 55	10 ~ 12.8	30.4	-0.9	
Mangosteens	14 ~ 28	56	13.3	30	50	none	56 ~ 65	13.3 ~ 18.3			
Olives, Fresh Green	28 ~ 42	41 ~ 45	5 ~ 7.2	15	26	good	41 ~ 50	5 ~ 10	29.4	-1.4	
Oranges	21 ~ 90	38 ~ 48	3.3 ~ 8.9	15	26	fair	38 ~ 50	3.3 ~ 10	30.6	-0.8	Some Florida-grown cultivars can be kept at 32-34°F. Arizona-grown Valencia oranges should be kept at 48°F.
Papayas, Mature-green	14 ~ 28	55	12.8	15	26	good	45 ~ 60	7.2 ~ 15.6	30.4	-0.9	Avoid setting temp below 45°F (chilling injury).
Papayas, Partially-ripe	14 ~ 28	50	10	15	26	good	45 ~ 60	7.2 ~ 15.6	30.4	-0.9	Avoid setting temp below 45°F (chilling injury).
Papayas, ripe	14 ~ 28	45	7.2	15	26	good	45 ~ 60	7.2 ~ 15.6	30.4	-0.9	Avoid setting temp below 45°F (chilling injury).
Passion Fruit	14 ~ 21	45 ~ 50	7.2 ~ 10	45	77	none	45 ~ 60	7.2 ~ 15.6			Avoid setting temp below 41°F (chilling injury).
Peaches & Nectarines	14 ~ 28	32	0	15	26	good	30 ~ 36	-1.1 ~ 2.2	30.4	-0.9	Avoid temp range 36-50°F. There are approx. 350 cultivars in Calif. Shelf life varies among them.
Pears, Anjou, Bosc & Comice	120 ~ 180	31	-0.6	15	26	excellent	30 ~ 36	-1.1 ~ 2.2	28 ~ 29	-2.2 ~ -1.7	Winter pear varieties can be stored in CA for up to 4 months (Bosc & Comice) or 6 months (Anjou). Note: do not accept pear bookings when pears are already near their post-harvest life expectancy.
Pears, Asian (20th-Century, Shinseiki, Ya Pear)	120 ~ 180	32	0	15	26	excellent	31 ~ 41	-0.6 ~ 5	29	-1.7	
Pears, Bartlett	90 ~ 180	32	0	15	26	excellent	30 ~ 44	-1.1 ~ 6.7	29.2	-1.6	
Pepino - Mellow Fruit, Treemelon	28 ~ 42	45 ~ 50	7.2 ~ 10	closed	closed	no published information	40 ~ 60	4.4 ~ 15.6			Avoid longer storage at 45°F or below (chilling injury).
Persimmons, Fuyu	25 ~ 84	32	0	15	26	good	30 ~ 44	-1.1 ~ 6.7	28.1	-2.2	
Persimmons, Hachiya	50 ~ 90	32	0	15	26	good	30 ~ 44	-1.1 ~ 6.7	28.1	-2.2	
Pineapples, Ripe	14 ~ 28	45 ~ 50	7.2 ~ 10	15	26	fair	45 ~ 55	7.2 ~ 12.8	30	-1.1	Avoid setting temp below 45°F (chilling injury).
Pineapples, Partially-ripe	14 ~ 28	50 ~ 55	10 ~ 12.8	15	26	fair	45 ~ 55	7.2 ~ 12.8	30	-1.1	Avoid setting temp below 45°F (chilling injury).
Plaintains	10 ~ 35	48 ~ 59	8.9 ~ 15	15	26	no published information	46 ~ 68	7.7 ~ 20	30.6	-0.8	
Plums	7 ~ 56	32	0	15	26	good	31 ~ 46	-0.6 ~ 7.8	30.5	-0.8	Avoid temp window of 36-46°F (killing temp range).

Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
Pomegranates	60 ~ 90	41	5	15	26	excellent	32 ~ 51	0 ~ 10.6	27.6	-2.4	Longer storage in CA for more than 2 months should be kept at 50°F.
Pomeloes - Pummeloes	84	45	7.2	15	26	no published information	45 ~ 60	7.2 ~ 15.6			
Prunes	14 ~ 28	32	0	15	26	good	31 ~ 46	-0.6 ~ 7.8	30.5	-0.8	Avoid temp window 36-46°F (killing temp range).
Quince	60 ~ 90	32	0	30	50	no published information	31 ~ 44	-0.6 ~ 6.7	28.4	-2.0	
Rambutan	7 ~ 21	50 ~ 54	10 ~ 12.2	30	50	good	50 ~ 65	10 ~ 18.3			
Sapatas (Sapodilla & Mamey Sapote)	14 ~ 28	58	14.4	30	50	good	54 ~ 60	12.2 ~ 15.6			
Soursop - Guanabana	21	59	15	60	102	none	59 ~ 68	15 ~ 20			
Starfruit (Carambola)	28 ~ 42	42 ~ 50	5.6 ~ 10	15	26	no published information	40 ~ 55	4.4 ~ 12.8			
Strawberries	5 ~ 10	33	0.6	15	26	excellent	31 ~ 41	-0.6 ~ 5	30.6	-0.8	
Tamarilloes	36 ~ 70	37 ~ 39	2.8 ~ 3.9	30	50	no published information	37 ~ 50	2.8 ~ 10			
Tamarinds	21 ~ 28	45	7.2	closed	closed	none	45 ~ 60	7.2 ~ 15.6			
Tangerine/Mandarin	14 ~ 42	41 ~ 46	5 ~ 7.8	15	26	none/slight	38 ~ 50	3.3 ~ 10	30.1	-1.1	
Tomatilloes	21	55	12.8	closed	closed	none	55 ~ 60	12.8 ~ 15.6			
Uglifruit	14 ~ 21	40	4.4	closed	closed	none	40 ~ 50	4.4 ~ 10	30.1	-1.1	
Watermelons, Seeded or Seedless	14 ~ 21	50 ~ 59	12.2 ~ 15	15	26	none/slight	50 ~ 60	10 ~ 15.6	30.9	-0.6	Watermelons are prone to chilling injury when stored at 45°F or below.
CUT FLOWERS											
Alstroemeria	14 ~ 21	33 ~ 36	0.6 ~ 2.2	15	26	slight	32 ~ 38	0 ~ 3.3	31	-0.6	Freezing damage may occur at temp below 31°F.
Anthurium	14 ~ 21	55	12.8	15	26	good	32 ~ 38	0 ~ 3.3	31.2	-0.4	Chilling injury will occur at temp below 50°F.
Carnation	14 ~ 28	34	1.1	15	26	no published information	32 ~ 38	0 ~ 3.3	31	-0.6	Freezing damage may occur at temp below 31°F.
Christmas Trees	30+	32	0	15	26	no published information	30 ~ 60	-1.1 ~ 15.6	N/A		Suggest spraying fresh water to the trees prior to closing the container doors.
Chrysanthemum	21 ~ 28	32	0	15	26	none	32 ~ 38	0 ~ 3.3	30	-1.1	Freezing damage may occur at temp below 30°F.
Flower Bulbs, Crocus/ Daffodil/Iris, Tulip	42+	63	17.2	15	26	no published information					
Flowering & Foliage Plants	42+	59	15	75	127	no published information					
Freesia	7	36	2.2	15	26	none	32 ~ 38	0 ~ 3.3	31	-0.6	Freezing damage may occur at temp below 31°F.
Ferns	30+	36	2.2	15	26	no published information	32 ~ 38	0 ~ 3.3	N/A		
Lisianthus	N/A	33	0.6	15	26	no published information	32 ~ 38	0 ~ 3.3	31	-0.6	Freezing damage may occur at temp below 31°F.

Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
FRESH MEAT											
Beef	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
Buffalo	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
Horse	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
Lamb	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
Pork	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
Poultry	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
Poultry, Ice Packed	14 ~ 65	33	0.6	closed	closed	excellent	27 ~ 33	-2.8 ~ 0.6	27	-2.8	
Veal	14 ~ 65	28 ~ 32	-2.2 ~ 0	closed	closed	excellent	28 ~ 33	-2.2 ~ 0.6	28.4	-2.0	
PROCESSED MEAT											
Bacon (Slabs or Sliced)	21 ~ 28	29 ~ 32	-1.7 ~ 0	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
Beef, Dried	21 ~ 28	29 ~ 32	-1.7 ~ 0	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
Beef, Sliced	21 ~ 28	41	5	closed	closed	good	29 ~ 41	-1.6 ~ 5	29	-1.7	
Cold Cuts	21 ~ 28	29 ~ 32	-1.7 ~ 0	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
Franks	21 ~ 28	29 ~ 32	-1.7 ~ 0	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
Hams, Baked	21 ~ 28	29 ~ 32	-1.7 ~ 0	closed	closed	good	28 ~ 41	-2.2 ~ 5	29	-1.7	
Hams, Boiled	21 ~ 28	29 ~ 32	-1.7 ~ 0	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
Hams, Smoked	21 ~ 28	27	-2.8	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
Sausages	21 ~ 28	27	-2.8	closed	closed	good	27 ~ 41	-2.8 ~ 5	29	-1.7	
DAIRY											
Butter, Fresh		34	1.1	closed	closed		38 ~ 48	3.3 ~ 8.9			
Butter, Frozen		0	-17.8	closed	closed		0 ~ 5	-17.8 ~ -5			
Cheese Foods		45	7.2	closed	closed		40 ~ 50	4.4 ~ 10	29	-1.7	
Cheeses, Natural - Cheddar, Cottage, Roquefort, Swiss		33 ~ 34	0.6 ~ 1.1	closed	closed		30 ~ 39	-1.1 ~ 3.9	29	-1.7	
Cheeses, Processed - American, Brick		45	7.2	closed	closed		30 ~ 50	-1.1 ~ 10	29	-1.7	
Chocolate		50 ~ 60	10 ~ 18	closed	closed						Dehumification is recommended.
Eggs	180	34	1.1	closed	closed		32 ~ 45	0 ~ 7.2	31	-0.6	
Ice Cream		-15	-26.1	closed	closed		0 or below	-17.8 or below			
Margarine		0	-17.8	closed	closed		35 ~ 40	1.7 ~ 4.4			
Milk		33 ~ 34	0.6 ~ 1.1	closed	closed		32 ~ 39	0 ~ 3.9			
FROZEN HORTICULTURAL											
French Fries		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Fruits		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Vegetables		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			

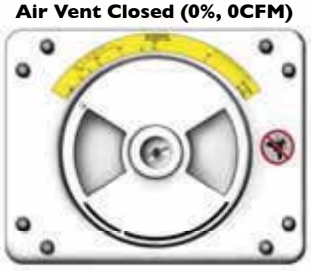
Commodity	Post-harvest Life (days)	Recommended Temperature Settings		Recommended Fresh Air Exchange		Benefit from Modified/ Controlled Atmosphere	Acceptable Receiving Pulp Temperature Range		Highest Freezing Point		Remarks
		°F	°C	(CFM)	(CMH)		°F	°C	°F	°C	
FROZEN MEAT											
Beef		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Buffalo		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Horse		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Lamb		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Pork		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Poultry		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Veal		0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
FROZEN SEAFOOD											
Crabs	120 ~ 360	0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Fish, Fatty - Herring, Mackerel	120 ~ 240	0 ~ -5	-17.8 ~ 20.6	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Fish, Lean - Cod, Flounder, Pomfret	240 ~ 300	0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Lobsters	120 ~ 360	0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Scallops	120 ~ 360	0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Shrimp	120 ~ 360	0	-17.8	closed	closed		0 ~ 15	-17.8 ~ -9.4			
Surimi	120 ~ 360	-15	-26.1	closed	closed		0 or below	-17.8 or below			
MISCELLANEOUS											
Batteries		45	7.2	closed	closed						
Leather		65 ~ 72	18 ~ 22	closed	closed						

Note:
The above mentioned temperature and fresh-air exchange settings for each commodity are only recommended set points.
The post-harvest life expectancy and best temperature management for each commodity also vary by cultivars and post-harvest handlings.
Recommended temperature and fresh-air exchange settings are for general guidance only. These recommendations are based on standardized assumptions and industry research. Optimum settings may differ depending on the specific commodity, post-harvest handling and other variables. Shippers are responsible for determining the optimum settings best suited for their cargo.

Fresh air exchange rate conversion (Carrier)

Vent % Open	R20 Container		R40 Container	
	CFM	CMH	CFM	CMH
0	0	0	0	0
5	14	23	11	19
10	32	54	26	44
15	39	67	30	50
20	59	101	45	77
25	68	116	53	90
30	79	135	62	106
35	90	152	71	120
40	102	173	81	138
45	115	196	93	157
50	128	217	103	175
55	131	222	106	180
60	136	231	110	187
65	141	239	114	194
70	145	247	118	200
75	148	251	121	205
80	155	263	126	214
85	159	270	129	220
90	163	277	133	226
95	168	286	137	233
100	174	295	141	240

Air Vent Closed (0%, 0CFM)



Air Vent Open (15%, 30CFM)

Fresh air exchange rate conversion (Daikin)

Ventilator Gate Opening		Fresh Air Flow Rate
(%)	CFM	CMH
100	147	250
95	140	238
90	132	225
85	125	213
80	118	200
75	111	188
70	103	175
65	96	163
60	88	150
55	81	138
50	74	125
45	67	113
40	59	100
35	52	88
30	44	75
25	37	63
20	29	50
15	22	38
10	15	25
5	8	13
0	0	0

Air Vent Closed (0%, 0CFM)

Air Vent Open (20%, 29CFM)

Fahrenheit/Celsius degree conversion

°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C
-35	-37.2	-15	-26.1	5	-15.0	25	-3.9	45	7.2	65	18.3
-34	-36.7	-14	-25.6	6	-14.4	26	-3.3	46	7.8	66	18.9
-33	-36.1	-13	-25.0	7	-13.9	27	-2.8	47	8.3	67	19.4
-32	-35.6	-12	-24.4	8	-13.3	28	-2.2	48	8.9	68	20.0
-31	-35.0	-11	-23.9	9	-12.8	29	-1.7	49	9.4	69	20.6
-30	-34.4	-10	-23.3	10	-12.2	30	-1.1	50	10.0	70	21.1
-29	-33.9	-9	-22.8	11	-11.7	31	-0.6	51	10.6	71	21.7
-28	-33.3	-8	-22.2	12	-11.1	32	0.0	52	11.1	72	22.2
-27	-32.8	-7	-21.7	13	-10.6	33	0.6	53	11.7	73	22.8
-26	-32.2	-6	-21.1	14	-10.0	34	1.1	54	12.2	74	23.3
-25	-31.7	-5	-20.6	15	-9.4	35	1.7	55	12.8	75	23.9
-24	-31.1	-4	-20.0	16	-8.9	36	2.2	56	13.3	76	24.4
-23	-30.6	-3	-19.4	17	-8.3	37	2.8	57	13.9	77	25.0
-22	-30.0	-2	-18.9	18	-7.8	38	3.3	58	14.4	78	25.6
-21	-29.4	-1	-18.3	19	-7.2	39	3.9	59	15.0	79	26.1
-20	-28.9	0	-17.8	20	-6.7	40	4.4	60	15.6	80	26.6
-19	-28.3	1	-17.2	21	-6.1	41	5.0	61	16.1	81	27.2
-18	-27.8	2	-16.7	22	-5.6	42	5.6	62	16.7	82	27.8
-17	-27.2	3	-16.1	23	-5.0	43	6.1	63	17.2	83	28.3
-16	-26.7	4	-15.6	24	-4.4	44	6.7	64	17.8	84	28.9

C = 5/9 (F - 32)
F = 9/5 (C - 32)

Reefer equipment technical specifications

Equipment	Exterior Dimensions (ft/meter)			Interior Dimensions (ft/meter)						Tare	Max Cargo	Cube	Cooling cap at 1.7C (35F)
	Length	Width	Height	Length	Width	Height	Cargo Height	Door Width	Door Height				
R20 (Steel)	20' 6.06 m"	8' 2.44 m	8' 6" 2.59 m	17' 10" 5.45 m	7' 6" 2.3 m	7' 5" 2.27 m	7' 3" 2.22 m	7' 6" 2.29 m	7' 5" 2.26 m	6,460 lbs 2,930 kg	60,740 lbs 27,550 kg	999 ft³ 28.3 m³	35,000 btu/hr 8,820 kcal/hr
R40 (Steel)	40' 12.19 m	8' 2.44 m	9' 6" 2.9 m	38' 11.59 m	7' 6" 2.3 m	8' 4" 2.55 m	8' 4" 2.55 m	7' 6" 2.29 m	8' 5" 2.57 m	10,100 lbs 4,580 kg	64,860 lbs 29,420 kg	2,400 ft³ 68 m³	36,000 btu/hr 9,077 kcal/hr

Generator set technical specifications

Manufacturer	Type	Rating KW	Output Volts	Engine Make	Model	#CYL	Hp	Cooling	Generator	Fuel Capacity	Tare Weight
Thermo King	Clip On	15	440	Yanmar	TK486	4	34.1	Water	Onan 15YD AL	125 gals	1,860 lbs
Thermo King	Underslung	15	440	Yanmar	TK487	4	34.1	Water	Onan 15YD AL	75 gals	1,510 lbs
Carrier	Clip On	15	440	Kubota	V2203L-DI	4	34	Water	Marathon Electric	130 gals	1,795 lbs
Carrier	Underslung	15	440	Kubota	V2203L-DI	4	34	Water	Marathon Electric	68 gals	1,650 lbs

Container Loading Checklist

- [ ] Refrigeration unit is operational
- [ ] Container is not damaged
- [ ] Door seals are in good condition
- [ ] Container is odor-free
- [ ] Container interior is clean, no debris blocking floor or drains
- [ ] Generator is operating and has sufficient fuel
- [ ] Microprocessor controller is set to correct temperature (check for Celsius or Fahrenheit)
- [ ] Fresh air exchange rate is set properly, check for cubic feet per minute (cfm) or cubic meters per hour (cmh)
- [ ] Humidity setting is correct
- [ ] 'Trip start' input for the microprocessor recorder
- [ ] Container passes air leakage test (for CA/RA)
- [ ] Container identification is documented
- [ ] Remove unwanted heat from the walls by pre-cooling to the appropriate loading temperature
- [ ] Cargo is at specified pulp temperature
- [ ] Correct cargo is loaded into container
- [ ] Cargo is properly stowed, stable and loaded below the red line
- [ ] Cargo is not stowed overly tight in flat wall containers
- [ ] Package count is correct
- [ ] Mark position of recorders, air bags and other details of stowage
- [ ] Security seal number is recorded
- [ ] Security seal is properly attached to rear door of container
- [ ] Call APL customer service if you have any queries

References:

Carrier Corporation. 1999. Controlled Atmosphere Handbook, A Guide for Shipment of Perishable Cargo in Refrigerated Containers.

Hardenburg, R., A. E. Watada, and C. ㄚ Wang. 1986. The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks. USDA Agriculture Handbook No. 66.

Kader, Adel A. 2002. Postharvest Technology of Horticultural Crops (Third Edition). Publication 3311, Division of Agriculture and Natural Resources, University of California, Berkeley.

Kohler, F and D. Birk. 1986. The Banana, Facts and Figures Concerning an Exceptional Fruit. The Transport of Perishable Foodstuffs, Cambridge Refrigeration Technology. Thompson, J. F., P E. Brecht, T Hinsch, and A. A. Kader. 2000. Marine Container Transport of Chilled Perishable Produce. Publication 21595, Division of Agriculture and Natural Resources, University of California, Berkeley.

APL

www.apl.com