Reefer Vessels – an Introduction

Part 1. Types of Ships and their specialized requirements – Reefer Vessels
Part 2. Training of the Crew-Safety & Environmental on Reefer Vessels.
Part 3. SOLAS convention and its application as applicable to cargo securing arrangements on reefer vessels will be demonstrated.

Part 1. Types of Reefer Ships and their specialized requirements-

This study will examine one of the most uncommon of merchant vessels – the Reefer Vessel. The total number of reefer ships world-wide today is about 1000 (reefers above 100.000 ft^3). The topics discussed will include-

- i) General Information.
- ii) Vessel Structure and design developments.
- iii) Specialized Equipment.
- iv) New Developments in Reefer Carriage.

General-

Concept
Transporting perishable cargo has always required special thought, equipment and care. Refrigeration is required to prevent natural decomposition. A common agent of decomposition in chemistry is heat, which can reduce both inorganic and organic compounds to their natural constituents. Refrigeration is applied to goods to minimize this process. In the case of fruit cargo (living cargo), the cooling process is used to reduce the metabolic processes that would normally lead to ripening. Advances in technology have now led to reefer carriage in "inert atmospheres", commonly known as Controlled Atmosphere (CA) carriage.

Reefer Ships:
A reefer ship is a cargo vessel that specializes in carriage of cargo that requires to be maintained at temperatures other than the ambient temperature. Reefer vessels are not conventionally described in terms of the usual tonnage values. A reefer ship size is more aptly illustrated in cubic capacity.

The cargo holds of a reefer ship are most unlike those found on their predecessors, the general cargo ship. Each cargo carrying space is lined by layers of insulation material that effectively reduces its volumetric cargo capacity. The insulation is necessary by the very nature of its trade.

Furthermore, the hold (usually the floor), is double skinned to allow for even circulation of the cooling air. Usually this affected by wooden gratings with precisely measured air passage openings that allow the cold air to percolate upwards through the cargo.

The cargo may be carried loose (in bins), in individual boxes or in pallets.

A typical reefer ship has today about 7000m^2 reefer hold for pallet cargo, or equivalent to about 600.000 ft^3.

In addition a ship of the existing types can carry about 100 - 300 loaded forty feet containers.

Most reefer ships operate at higher cruising speeds, usually 18 - 23 knots, primarily reducing carriage times of perishable fresh fruit and of course allowing operational flexibility and to decrease turnaround times.

Reefer vessels are able to carry any frozen or cooled cargo including fruits, vegetables, fish and meat. The temperature range is -30 to +12 ºC depending on the type of cargo. The most sensitive cargo prevalent is that of fresh Bananas.

Total number of ships:
The total number of reefer ships world-wide today is about 1000 (reefers above 100.000 ft^3). New buildings and designs are always under consideration.

Vessel Structure and design developments-

Reefer designs have undergone various changes over the years. Some are common to all vessel types – cargo handling gear, engine design, etc. The reefer trade has been dominated the most with carriage of bananas and we will discuss this in particular.

Some 20 years ago, banana carriage was achieved by directly hanging bunches of banana in specially designed bins (much like the garbage bins of today). In later years, the fruit was transported in boxes, which were stored individually by hand in the cargo holds. Of course, nowadays, the carriage has progressed to the practice of palletised carriage which leads to more efficient handling.

Container transport in the reefer trade has also dramatically increased.

Banana Republic is a disapproving term, defined in the dictionary as a small country with an unstable government, typically a military dictatorship, and an economy dependent on the export of a single product or on outside financial help. This term is mentioned here with good reason. Most reefer fruit trade originates from areas where such conditions had once prevailed. As a result, reefer ships were not exposed to many port facilities in their load ports. This factor also largely contributed towards vessel design (the advent of side door reefers).

To counter the loss of space due to insulation in the holds, reefers were usually designed with dual purpose DB tanks. This allowed a vessel to load maximum cargo with bunkers in the load port. As the fuel was consumed, the resulting empty bunker tanks were ballasted as required by stability needs. A more modern approach is applied today in compliance with Marpol and all prevailing rules and regulations.

Conventional reefers

Conventional vessels carry both palletized cargo and cargo stowed loose in the cargo holds. Quality is as important for these vessels as for any other vessels. Cargo handling and stowing is made easy with efficient gear and a minimum of stanchions in the holds.

Sidedoor reefers

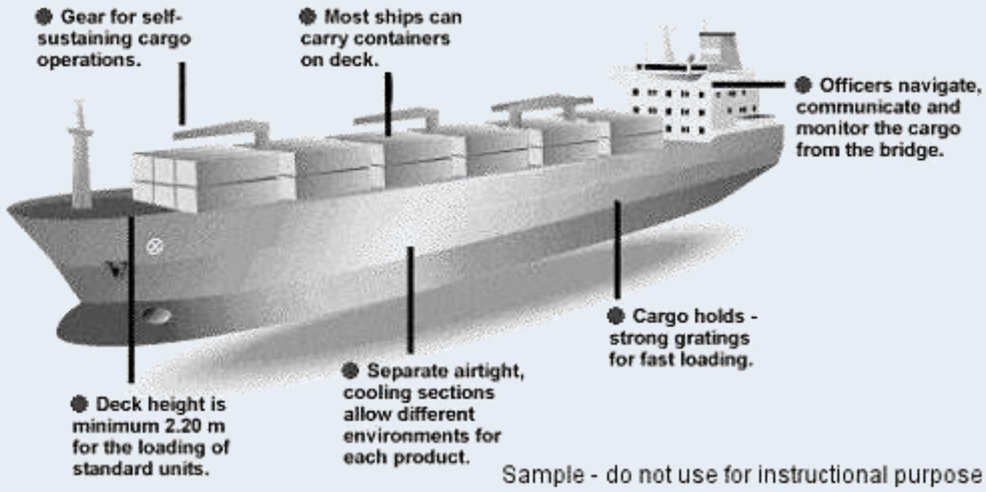
A number of vessels have sidedoors - equipped for fast, careful and economical handling of the cargo onboard the ship. Loading and discharging via the ships' sidedoor and cargo elevators enables the vessels to load and discharge irrespective of tidal variations. For loading, the cargo is placed on the ships' cargo elevators, elevated to the relevant loading deck, where the cargo is stowed in final position by the forklift. The sidedoor also allows for loading and discharging in bad weather conditions, and temperature losses through open hatch covers are kept to at a minimum.

Reefer Vessels are designed for speed and not for comfort. They are amongst the most uncomfortable ocean going vessels and move easily to even slight seas and swell. It takes a special kind of sailor to operate these ships. A sample reefer ship: LOA 150m, B- 20m, BHP- 10,000, 4 holds, 4 decks per hold.

A reefer ship design also incorporates more pipelines than on most tankers. These lines are the refrigerant lines, which lead to each cargo space. Usually, this refrigerant is the secondary cooling element and is brine. These brine lines lead to a "cooling battery" pair located in each deck (a total of 16 in the sample ship mentioned above). Each such brine line feeds a bank of cooling coils per battery, which cools the forced airflow generated by 8 to 12 cooling fans over each such coil.

Containerised Reefers

The container trade is fast catching on in the reefer world. Since the mid 1980s, many reefer vessels were built to cater to such cargo carriage. Usually the deck space is utilised for container carriage.



A modern day Reefer Ship

Some vessels are container fitted with a capacity of upto 400 TEU. Some very specialised fully containerised reefer vessels are also in service of late.

Specialized Equipment on Reefers

Reefer ships require the following for effective carriage-

i) A cargo cooling system. This entails the incorporation of a cargo cooling plant. Usually a bank of compressors are used which cool refrigerant gas (freon is most in use). This cold freon in turn cools the secondary refrigerant which is usually brine. The brine is circulated to all cargo spaces and through cooling (evaporating coils) fitted under powerful fans. The subsequent air flow cools the cargo. The system is comparable to the modern day air-flow home refrigerators marketed these days.

ii) As is obvious, defrosting needs to be affected when freezing temperatures are maintained – as often as 2-3 times a day on occasion. Hence powerful heating apparatus needs to be fitted.

iii) Effective control systems to meet precision temperature requirements.

iv) Higher capacity generators to meet the power needs.

v) Special monitoring equipment (computerised or manual) for safe monitoring of equipment and cargo.

vi) Effective ventilation control systems. High level of humidity needs to be maintained. A reefer vessel can ill afford weight loss from cargo due to low humidity level.

vii) Extra hold bilge-pumping requirements. After loading, due to rapid forced drop in temperatures, condensation leads to large water accumulation and needs to be controlled.

viii) Modern reefer vessels also incorporate Inert gas generators and systems – thus cooling and atmosphere control are both applied to the cargo.

New Developments in Refrigerated transport.

This section will mostly discuss one of the latest developments in reefer transportation. Reefer carriage traditionally entailed keeping the goods in suspended animation – so to say, by bringing down the temperature of the cargo. Research and experimentation showed that by limiting availability of oxygen to fresh fruit further inhibited the natural ripening process.

Imagine that you are exposed to very low temperatures. Your breathing slows down, your heart rate reduces and you will in time end up in a state similar to hibernation. What would happen if someone at the same time also chose to choke your air supply – you would turn unconscious much earlier. Mind you, the temperature cannot be too cold or your body will freeze and stop to function. Neither can you be denied all oxygen as that would lead to asphyxiation.

A similar condition is generated on board vessels for the live fruit forcing them to go into a state similar to hibernation. The oxygen denial is applied by using inert gas generators that are now increasingly found on reefer vessels. Inert atmospheres now are no longer the domain of oil tankers.

Application of this technology manifests in what is called Controlled Atmosphere (CA) Transportation in the reefer world.

Even the simpler temperature control carriage requirements are being modified because of technology. Gone are the days when a degree on either side of carriage requirement was acceptable. If bananas need to be carried at 13.3°C, then that is the temperature that must be maintained. It is apt to point out that with the greater control that technology affords us, the fruit can be kept on the mother plant for a longer period – thus enhancing its size, weight and marketability. The catch lies in the fact that the longer one delays harvesting the produce, the closer it reaches maturity. It is then more likely to ripen if the precise storing conditions are not met and in turn lead to turning of other cargoes!!!

The carriage temperatures defined are also undergoing changes. For example, studies have revealed that bananas may be carried at 12.8°C or 13.3°C or 13.5°C depending on the soil the plant rooted in, the thickness of the skin, the… etc.

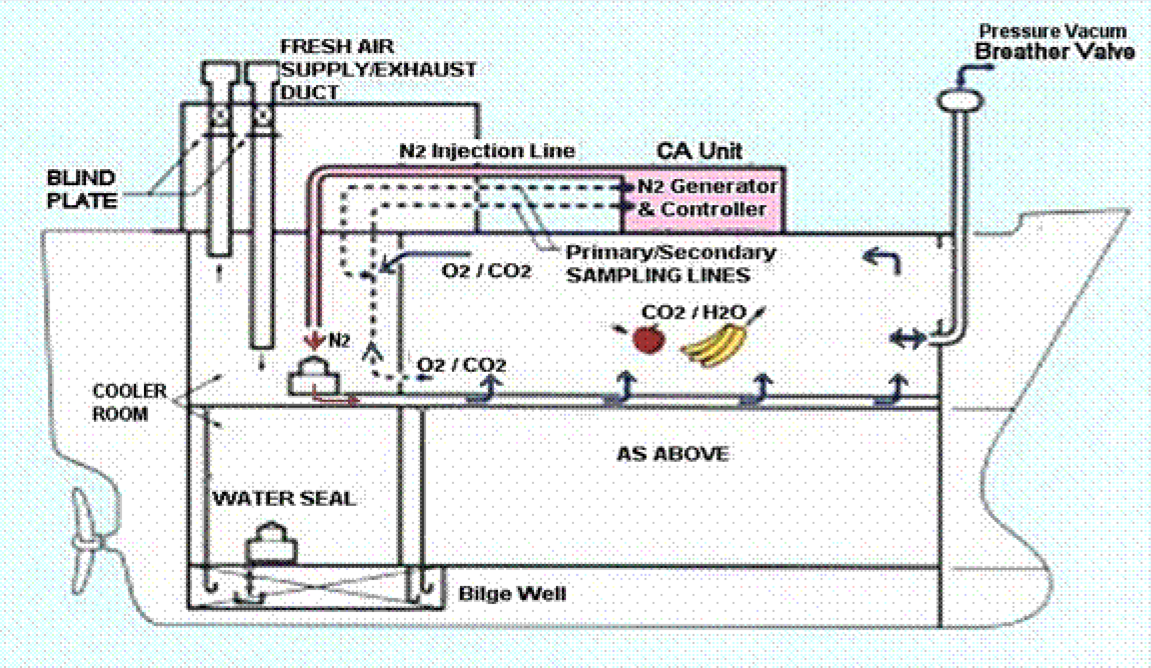
Controlled atmosphere technology works by reducing produce respiration, slowing ethylene production, inhibiting pathogen reproduction, and killing insects. The greatest impact on insects is achieved by maintaining low Oxygen concentrations for an extended period of time which leads to O^2 deprivation in insect body tissues. At exposure concentrations of 0.5 percent O^2 for 96 hours, 100 percent mortality has been observed for nearly all insects tested.

Controlled Atmosphere (CA) in Transportation

The old concept of measuring shelf life of fresh produce in weeks or months is now obsolete. With CA carriage, shelf life is now measured in BTUs (thermal units indicate metabolic life). The ripening of fruit can be successfully manipulated by utilising CA technology during transit, thus extending the cargo's shelf life. Atmospheric components such as O^2 and CO^2 are manipulated to create an environment that restricts the respiration process of fresh produce and helps to impede fungal growth.

Controlled atmospheres are essentially those which deviate from the normal air composition of 21% oxygen, 78% nitrogen and 300ppm of carbon dioxide. Other gases are also present but normally in too small a concentration to have a prime effect on stored produce.

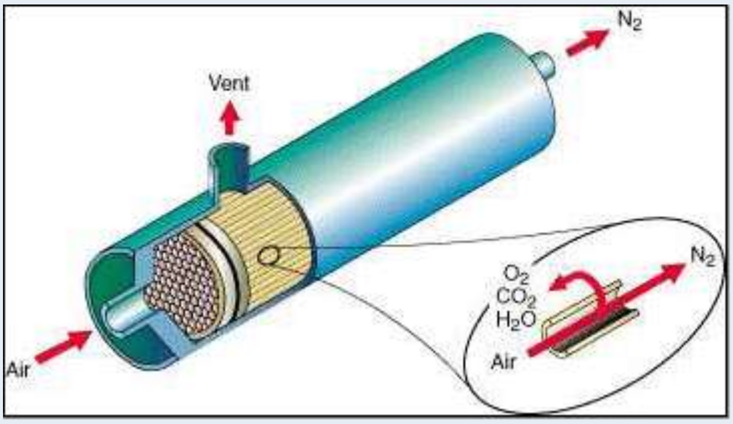
The most common inerting gas used is Nitrogen. Special generator units are employed to extract the atmospheric Nitrogen (reducing O^2 content). The resulting air mixture is then pumped into the cargo holds, purging the existing mass of air. The atmosphere in the hold is controlled to preset levels (depending on fruit) and CA carriage requirements complied with.



Schematic - CA Reefer System

The principle technologies employed for transportable CA systems have included Membrane type N^2 Generators, PSA (pressure swing adsorption) type Generators or stored gas (Air transport usually).

HOW MEMBRANE TECHNOLOGY WORKS

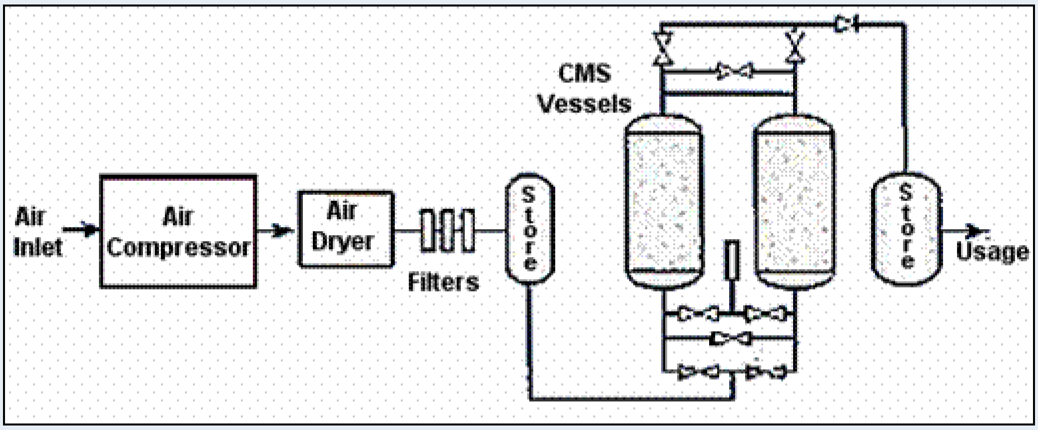


Compressed air enters one end of a permeable membrane. The membrane is comprised of many hollow fibres. The N^2 travels the length of the fibres and exits at the other end of the membrane. The O^2 in the air passes through the sidewall of the fibres and exits the side of the membrane.

Prior this basic process, the air mixture is treated to remove contaminants, moisture, etc.

HOW PSA TECHNOLOGY WORKS

Compressed air enters one end of two absorber tubes . . . filled with carbon molecular sieve (CMS). While the smaller oxygen molecules are absorbed by the CMS, the larger nitrogen molecules pass through and are stored. Upon stauration, the first adsorber releases the oxygen, which the second adsorber starts the process over again.



After about one minute adsorption in one adsorption tower the process controller is switching over to the second tower and the first one is regenerated.

Controlled Atmosphere (Inert Gas) requirements are very precise and require careful monitoring and control. If the O^2 level falls below the requirement, the fruit will perish and never ripen. You will loose your job!!!

Responses of Fruits to Controlled Atmospheres (CA)

Bananas

- At 2-5% O^2 and 2-7% CO^2
- CA delays ripening and reduces respiration and ethylene production rates.
- Postharvest life potential of mature-green bananas: 2-4 weeks in air and 4-6 weeks in CA at 14°C (58°F)
- Exposure to<1% O^2 and/or >7% CO^2 may cause undesirable texture and flavor.

- Use of CA during transport to delay ripening has facilitated picking bananas at the full mature stage.

Apples

- Fruit to be stored longer than one month benefit from CA storage in terms of retention of flesh firmness, acidity, and skin color. CA storage potential is up to 10 to 24 months (vs. 6 months in air).
- Recommended atmospheres: 1 to 3% O 2 + 1.5 to 3% CO2

An example of required parameters is shown in the tables below.

The parameters for oxygen and CO^2.

Banana and Pineapple cargo.

Gas	Range	Level	%	
O2	In-Range	High	4.0%	
O2	''	Low	2.1%	
CO2	''	High	5.5%	
CO2	''	Low	4.0%	
O2	Alarm	High	22.0%	
O2	''	Low	2.0%	
CO2	''	High	6.0%	
CO2	''	Low	0.0%	
O2	**Set point**	**High**	**3.2%**	**Delivery of inert gas.**
O2	''	Low	2.4%	Start introduction of balanced air.
CO2	**''**	**High**	**5.0%**	Start introduction of inert gas.
CO2	''	Low	0.0%	

Melons and Grapefruits Cargo.

Gas	Range	Level	%	
O2	In-Range	High	4.5%	
O2	''	Low	3.2%	
CO2	''	High	6.5%	
CO2	''	Low	4.0%	
O2	Alarm	High	22.0%	
O2	''	Low	3.0%	
CO2	''	High	7.0%	
CO2	''	Low	0.0%	
O2	**Set point**	**High**	**4.0%**	**Delivery of inert gas.**
O2	''	Low	3.4%	Start introduction of balanced air.
CO2	**''**	**High**	**6.0%**	Start introduction of inert gas.
CO2	''	Low	0.0%	

from a compilation by Capt. Kohli

Automated, computer controlled monitoring and control systems are employed by staff on board reefer vessels. The arduous and precise tasks of matching stringent reefer carriage requirements are aided by computerised equipment.

Another modern development in reefer vessels is the advancement in **Remote monitoring technology**. This is applied both to cargo holds and container units.

Remote monitoring technology works on the basis of logging the performance history of individual reefer units in transit for later transmission by e-mail. Usually data relay uses the same Transmission Control Protocol/Internet Protocol (TCP/IP) Protocol as used on Internet sites. This allows one to carry out both onboard and shore based monitoring via a ship's satellite communication system and the Internet. At the same time the user is able to view container location (bay-row-tier), point of origin and destination.

Part 2. Training of the Crew-Safety & Environmental

Reefer vessel crew need to be explained the necessary techniques that involve carriage of a perishable, edible commodity. Further, reefer trade involves cargo that will not undergo further processing but is loaded consumer ready.

The basic requirement is cleanliness. Reefer ships will accumulate fungal growths over a passage. This needs specialised equipment and material to remove.

The reefer equipment and its associated controls need careful understanding and training. Reefer crew is also made aware of the associated dangers with handling of chemicals and gases that are used in the reefer plant.

Environmental Issues - Reefer Vessels

The usual environmental issues applicable to all sea going vessels are not mentioned here. We discuss those peculiar to reefer vessels.

Effective **Refrigerant Control** is required on board Reefer Ships.

The topic of Refrigerants opens with a reminder about environmentally sensitive issues, holes in the ozone layer, global warming, skin cancer, etc.; there is good reason for this.

Sunny days have always been associated with warmth and pleasure until we discovered that certain gases used in refrigeration systems are destroying the protective ozone layer.

Many reefer ships rely on freon (a CFC) as the primary cooling agent. The critical factor is how carefully it is handled by the officers and crew members who are in charge of the systems which use this gas. Any escape of freon is harmful to the natural environment and also represents a hazard to those working on board.

The other coolant commonly used on board reefer ships is brine. This is corrosive and has its own potential for damaging the environment. For these reasons adequate training must be given to all those working with these systems.

The final message is the need to protect the environment by the careful handling of refrigerants, which has the added advantage of helping to run the ship more economically.

Reefer ships carry a great many time-dependent food cargoes that are easily damaged if **correct procedures** are not observed. There is need for careful examination of all cargoes before loading to check product quality and the importance of following the specified carriage conditions to ensure that this quality is not impaired during the voyage. Careful record-keeping is essential to ensure that any claims against the shipper can be properly dealt with.

When damaged fruit is encountered, it cannot be easily disposed off. The fruit is transported in its marketable form - packed in plastic and then stowed in branded cardboard boxes. Disposal involves separating these materials from their packing prior to any waste disposal. This is very labour intensive (imagine doing this for only one deck load of 15,000 boxes).

Dangers Involved in CA equipped vessels.

The dangers involved are unique. The following below, needs to be understood by all operators.

Do not approach a gas relief (PV) valve from the cargo holds even within 50 cm. The possibility of brain damage arises if even one breath of CA gas is taken. The crew must be well informed about this danger. Entering a dangerous compartment or entering while holding one's breath, even for a very short time, MUST not be done.

The officers and the crew on the CA ship must undergo training in the safe operation and the handling of the CA unit. New crewmembers must immediately undergo training when they arrive on the ship. The content of the training is as follows.

1. Understand the warning signs posted on board.
2. Method of using personal oxygen monitor.
3. Start of fresh air fans and the ship safety plan.
4. Emergency medical treatment using the oxygen resuscitator.

The training must be carried out using understandable, correct terms. The officer in charge of the safety for the ship must carry out the training periodically. The awareness of the danger concerning CA is especially important for all the officers in order to always maintain a high safety for the crew. The officers should discipline the crew concerning doors to be locked, and the precaution before entering any CA rooms or compartments.

Entering cargo compartments.

CA cargo holds, by their very nature, are dangerous because of the low oxygen content of the atmosphere. No one should ever enter or even place their head inside an operating CA space. People have passed out, fallen into the room, and died just a few centimetres inside the doorway. Never enter alone, and never open a door or hatch without having at least one other person familiar with the hazard nearby.

Before entering any CA room or compartment-fresh air fans should always be operated. Never enter unless at least 20% oxygen in the room or compartment. During the ventilation time frequent measurements of the atmosphere inside the room or compartments to be monitored. Before entering any CA room the personal oxygen monitor must be calibrated to make sure the instrument operates correctly. When entering a room or compartment the personal oxygen monitor must always be used. Fresh air ventilation to be operated at full speed during the entire time of the entry. NEVER enter any room or compartment without the fresh air ventilation fan at maximum speed.

Symptoms of asphyxia.

The symptoms of asphyxia below should be familiar to all the crew and officers on the ship.

21% oxygen	Breathing normal, all functions normal.
17% oxygen	Candle is extinguished.

12 - 16 % oxygen	Breathing and pulse rate accelerated. Ability to maintain attention and to think clearly is diminished, but can be restored with effort. Muscular co-ordination for finer skilled movement is somewhat disturbed.
10 - 14% oxygen	Consciousness continues, but judgement becomes faulty. Severe injuries (burns, bruises, broken bones) may cause no pain. Muscular efforts lead to rapid fatigue, may permanently injure the heart, and induce fainting.
6 - 10% oxygen	Nausea and vomiting may occur. Legs give way, person cannot walk, stand or even crawl. This is often the first and only warning and it comes to late. The person may realise he is dying, but he does not greatly care. It is all quite painless.
Less than 6% oxygen	Loss of consciousness in 30-45 seconds if resting, and sooner if active. Breathing in gasps, followed by convulsive movements, then breathing stops. Heart may continue beating for a few minutes, then it stops.

Remember Holds under CA CONTAIN LESS THAN 5% OXYGEN

High Carbon Dioxide

In some circumstances such as ripening rooms or cargo holds containing respiring fruit, the CO2 produced by the fruit can, if insufficiently ventilated, build up to dangerous levels. Levels of CO2 exceeding 5% are regularly experienced in a banana cargo hold.

The upper limit for CO2 in rooms for human occupation are:

Continuous occupation (8 Hours) 0.5% CO2
15 minutes exposure 1.5% CO2

To ensure these levels are not exceeded in the cargo holds, ventilation before entering should always be carried out.

Method of rescuing a person who has collapsed due to lack of oxygen.

Use the following procedures for rescuing a person who has collapsed due to lack of oxygen at a danger area.

1. Sound the emergency alarm.
2. Close the CA supply valve or stop the compressors in the CA container.
3. Run the fresh air fans at full speed.
4. Open all the fresh air ventilation and exhaust covers.
5. Measure the ventilation air with an oxygen monitor to confirm the atmosphere in the area has normalised.
6. Confirm the oxygen has risen above 19%, and begin lifesaving operation.
7. If the victim's pulse or breathing has stopped, perform cardiopulmonary resuscitation (CPR). If there is a pulse and breath, the person will recover unassisted.

Some of the Reefer Ships headed by Capt. Kohli in over 14 years as Ship Master.


Dole


Dole


Dole
Dole


Dole