

WHITE PAPER

Cold Chain

Temperature-controlled supply chains





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Waste not, want not

The 'cold chain' market is growing faster than the world economy

According to reports by several research companies, the “cold chain” market has been growing at a much faster rate than the global economy.

By “cold chain”, we mean the distribution of food, beverages and pharmaceutical products, which all need to be kept at cold temperatures in order to maintain their freshness and quality and prevent deterioration and losses. Some call it the temperature-controlled supply chain.

A somewhat shocking statistic has it that approximately one-third of all the food in the world goes to waste, mainly because the temperature it is kept at is higher than the acceptable limit through the supply chain.

This is “totally unacceptable”, says the US government’s National Institutes of Health. In

a report, Reducing Food Losses by Intelligent Food Logistics, the NIH says: “A high share of these losses is related to non-optimized handling during supply chain processes.”

The NIH specifically studied fresh fruit and vegetables, but the same could be applied to beverages and pharmaceutical products, which also need to be stored at low temperatures and have relatively short shelf lives.

Developing solutions

In this white paper, we take a closer look at the “cold chain” as we have called it, and highlight the role that robotics and automation can play in ensuring fast movement of goods within cold warehouses and, therefore, in reducing losses and waste to a minimum. ■



A Fanuc robotic arm being used to move lettuce through a warehouse

Critical components of a cold supply chain

The logistics industry has seen many changes over the past few decades, with the increasing liberalisation of international trade and the continuing growth of e-commerce being driving factors. However, it is in the area of cold supply chains that there have the most recent dynamism.

One of the main reasons for this is that consumers increasingly expect to be able to order fresh produce – fruit, vegetables and other perishable items – online, and for the items to be delivered in perfect condition.

For the new generation of consumer, ordering an item such as a head of lettuce, which can lose its freshness within a day or two, is no different to ordering a piece of furniture. They may be mindful of the different logistical requirements for each type of item, but they simply expect the supply chain to be geared up to deal with perishables and non-perishables alike.

From the point of view of the logisticians and supply chain

Key technologies in the cold chain

The three key technologies that are essential to maintaining low temperatures all along the supply chain are refrigerated containers or trucks, cold storage and warehouses, and fast, efficient material handling robots.



Refrigerated containers

Whether they are integrated into a vehicle or not, cool containers are vital to the cold chain.



Cold warehouses

Also called cold stores, they are essential to eliminating rotting and insect damage.



Cold chain robots

Robotic material handling cuts the time perishable goods spend in warehouses and in transit.

A simple cold chain diagram can look like the one below, going from farm to retail. Efficient movement is critical, which is why robots are increasingly important in cold warehouses.



professionals, the critical requirement of perishables is that they need to be kept in temperature-controlled environments – meaning, cold. Every second a perishable item is left in temperatures above, say, 5°C is a second that it is deteriorating.

Some perishables can go off or become spoiled within minutes. And if that perishable makes a journey of several days' duration, it's technically very difficult to keep it cool all the way from the manufacturer to the customer, from the farm to the kitchen table, as it were.

For older generations of consumers, it may seem quite remarkable that highly complex, long supply chains can maintain the freshness of a perishable item across many thousands of miles, through several international borders, over several days. Lettuce harvested in southern Spain one day could be part of lunch the next day for someone in northern Germany; mango picked in Kenya one week could form part of a dessert the following week for someone in America.

Refrigerated containers and trucks, as well as cold storage and warehouses are essential to make such supply chains successful. And, increasingly lately, superfast warehouse robots have been reducing the length of time perishable items spend in transit, helping to shorten the overall duration of the journey between farm and table, thereby increasing efficiency and profits as well as reducing waste and losses. ■



Top markets for cold chain storage and transportation

The United States government produces in-depth reports about the cold storage and transportation market on a regular basis, in the belief that it is a “force multiplier” in an industry that can generate exports and open new markets in a variety of sectors over an extended period.

US companies are spending hundreds of millions of dollars each year to build and maintain cold chain systems against a background of \$750 billion of losses in the food industry alone each year. These losses primarily result from “lack of proper facilities, improper food safety handling procedures and insufficient training for those personnel working in the cold chain”, according to the International Trade Administration, which is part of the US Department of Commerce.

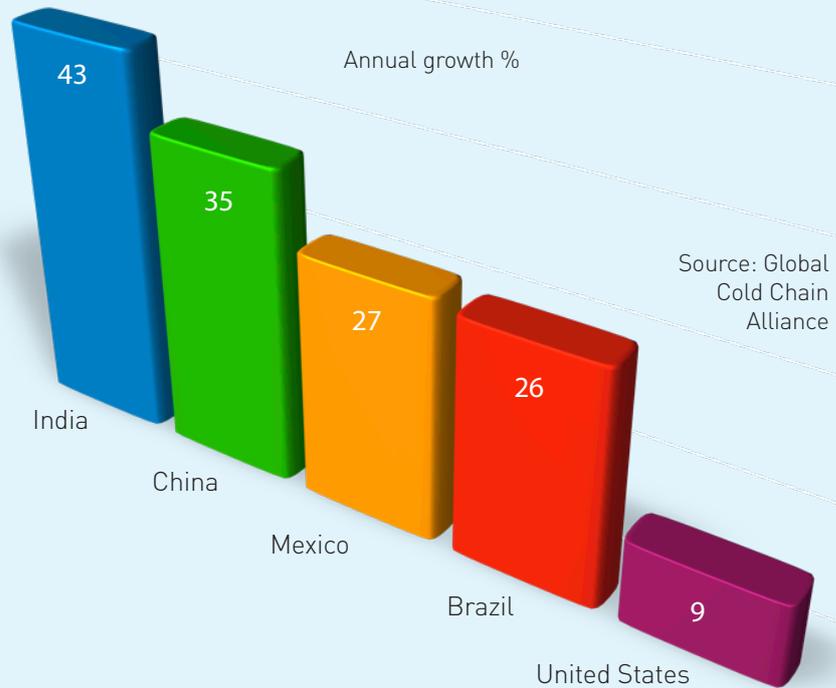
The individual technologies and components for cold chains has been around for some decades. However, it is only recently that cold chain has started to become viewed as a distinct

Refrigerated warehouse capacity growth

The infrastructure of a country is a key factor in evaluating its potential as an export market for cold chain equipment and technologies.

The International Association of Refrigerated Warehouses found a strong correlation between a country's cold storage capacity and its ranking in the World Economic Forum's Transportation Index – meaning, the better the country's transport infrastructure, the more likely it is to have a greater amount cold storage facilities.

That said, this chart only shows the countries with the biggest growth in cold storage capacity, as analysed by the Global Cold Chain Alliance – and does not evaluate any of the countries' respective infrastructures.



part of the logistics industry and studied and evaluated by governments and analysts. Some companies have already established large businesses based on cold chain, helping to efficiently move goods such as food, beverages, flowers and biopharma. Indeed, the ITA says that more than \$260 billion of annual biopharma sales are “dependent on cold chain logistics to ensure the efficacy of their products”.

In terms of export potential, the ITA highlights countries including Singapore, Netherlands, Japan, Germany and India as representing market opportunities for suppliers of cold chain equipment and services.

For governments as well as the cold chain industry, close co-operation is essential because there are additional regulations which apply when storing and transporting perishable items, not just for economic and business reasons, but also because spoiled food and drugs would potentially represent a threat to public health.

According to industry association Global Cold Chain Alliance, the countries with the fastest-growing cold chain industries are:

1. India43%
2. China35%
3. Mexico27%
4. Brazil26%
5. United States9%

Top refrigerated transportation manufacturers

Refrigerated trailers or trucks are sometimes called “reefers” for short, and have been growing as a market fast in recent years. Two of the companies on this list – Wabash National and Utility Trailer Manufacturing – have more than \$1 billion worth of annual sales revenue.

The growth and diversification in the market will probably enable new companies to emerge, perhaps with new technologies such as driverless vehicles and automated loading and unloading, for which the technology components are already available.



Source: Hoovers.com

Highly sensitive to temperature

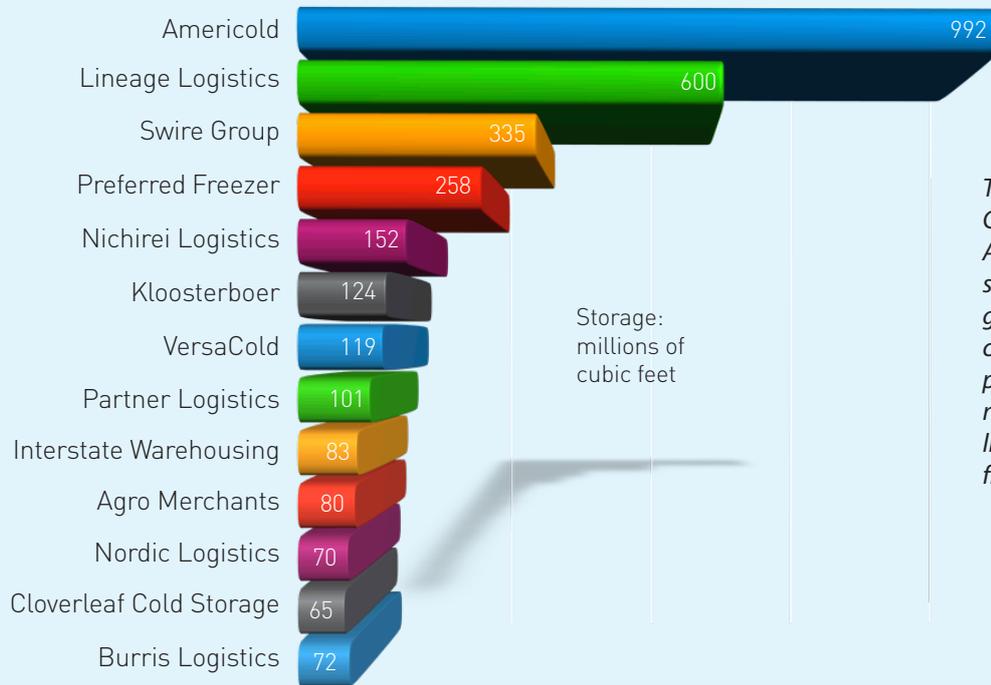
An end-to-end cold chain is only as efficient as and secure as the weakest link in the system. Each link in the cold chain must maintain the same or similar temperature for as much of the duration of the journey as possible. Otherwise, the customer will receive a sub-standard product or even one that is entirely unacceptable. Moreover, a single breakdown in the cold chain can result in significant losses of product, causing financial damage and risks to health.

Cold chain services that support perishable food distribution globally are valued at approximately \$250 billion. Cold chain logistics spending in the biopharma sector is estimated at more than \$13 billion, with Asia contributing \$1.2 billion in growth in the past year. The compound annual growth rate of cold chain markets is forecast to be almost 16 per cent this year.

The US is one of the leading developers of cold chain infrastructure, equipment and technologies, and the government wants to support companies in their push abroad. According to the GCCA, the global refrigerated warehouse capacity has been increasing annually by around 20 per cent, and three of the top five refrigerated warehouse operators are American companies.

The requirements for cold chain facilities vary based on the size, type and amount of product, along with the particular

Top cold warehousing companies by capacity



The US Department of Commerce is keen to help American providers of cold storage facilities to expand globally. The country currently has a strong position in the market, with nine of the 13 companies listed in this chart being from the United States.

Source: Global Cold Chain Alliance

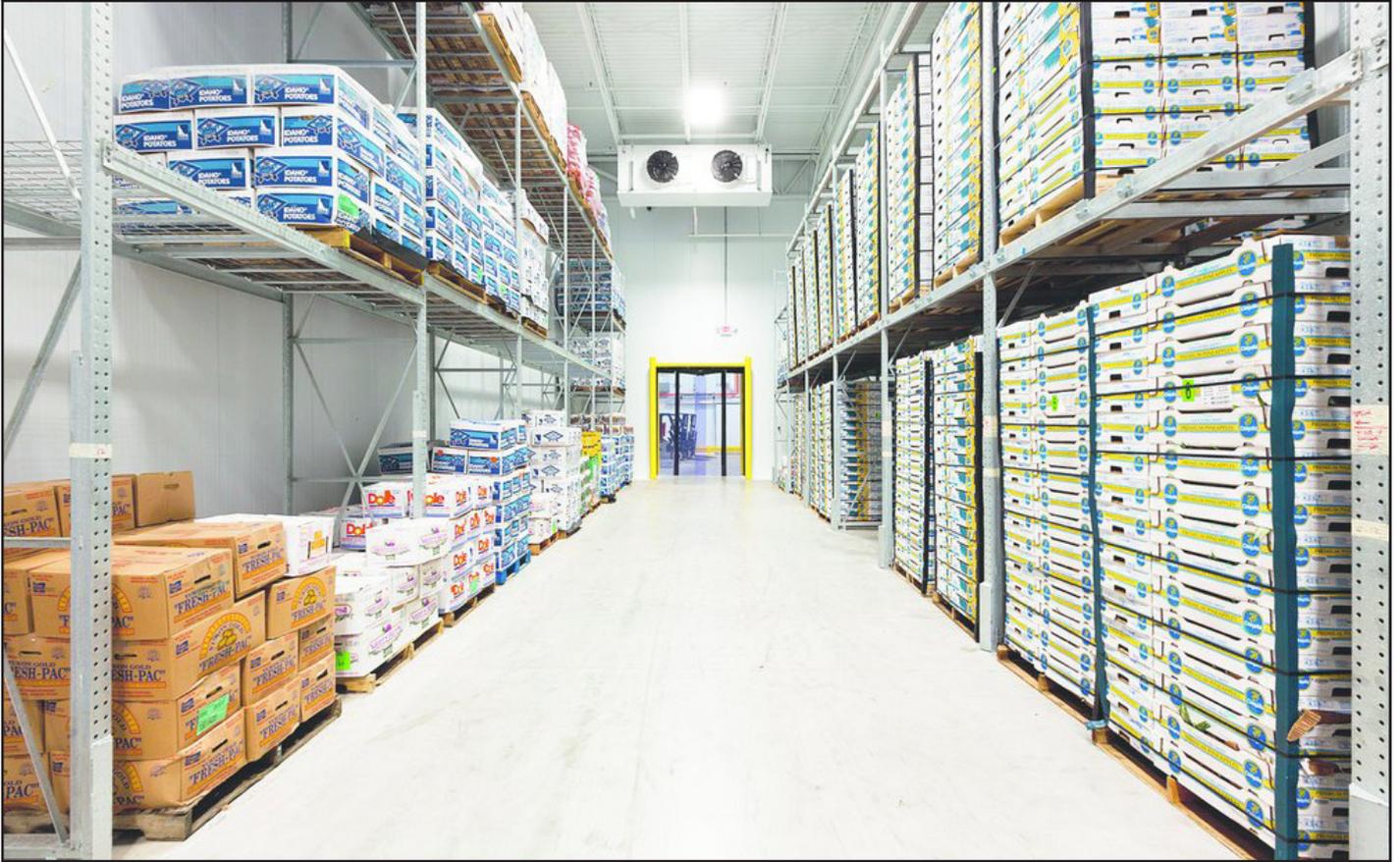
requirements of the customer. For example, fruits and vegetables often require cool temperatures of around 12°C. Most dairy products, meanwhile, require temperatures close to freezing, at around 1 or 2°C. Meat and poultry products need to be kept at below zero, at less than -2°C. And ice cream and other frozen products, of course, require temperatures way below freezing, from -20° to -100°C.

While large enterprises such as Walmart, McDonald's, Coca-Cola and others have the necessary resources to build their own cold chains, most other businesses rely on effective third-party logistics companies – including specialist cold storage providers – to enable them to offer fresh produce to their customers.

Among the largest cold storage providers are: Americold; Lineage Logistics; Swire Group; and Preferred Freezer.

In addition to cold storage, fast robots within the warehouses and express delivery to the customer using refrigerated containers and vehicles are helping to accelerate the growth of the cold chain industry as well as help deliver goods that are almost as fresh as they were when they were harvested on the farm or produced in the lab.

Companies such as Geek+ Robotics are offering specialised services for temperature-controlled warehouses, while logistics giants such as DHL, UPS and Fedex have been providing specialised cold chain solutions for some time. ■



Temperature-controlled global supply chains

Modern logistics and supply chain networks move goods at very high speeds compared with those of the past. Nowadays, goods are rarely, if ever, left sitting in warehouses or storage for weeks on end. At most, they may be stored a few days, but increasingly it's a matter of hours before they are transported again to their next destination.

This is, of course, a massive improvement on previous systems. And not only are logistics and supply chains faster, they are also more extensive. To say that a particular company has a global supply chain these days is not a big deal.

What is new, however, is that cold chains – or logistics and supply chains that require the product to be kept at a particular temperature to maintain the quality of the product – are also going global. In other words, however long and complex a product's journey, it is very likely that there are logistics and supply chain networks available that can keep it at the

Different temperatures for different products

Most of us may have fridge-freezers at home and know how to increase and decrease temperatures.

But we are not required by law or regulation to keep specific foods at specific temperatures, as are

suppliers of those foods. Below are the temperatures stipulated by the US authorities, although they

are very similar to limits set by most other advanced economies because of global regulation and trade.

0°F or below

Meat
Fish
Poultry
Frozen fruits
Vegetables
Ice cream

32°F to 50°F

Fresh fruits
Vegetables
Milk
Dairy products
Flowers
Eggs

50°F to 65°F

Sub-tropical fruits
Seeds
Chocolate

65°F or above

Processed foods
Pickles
Cooked foods
Cooking oils
Onions

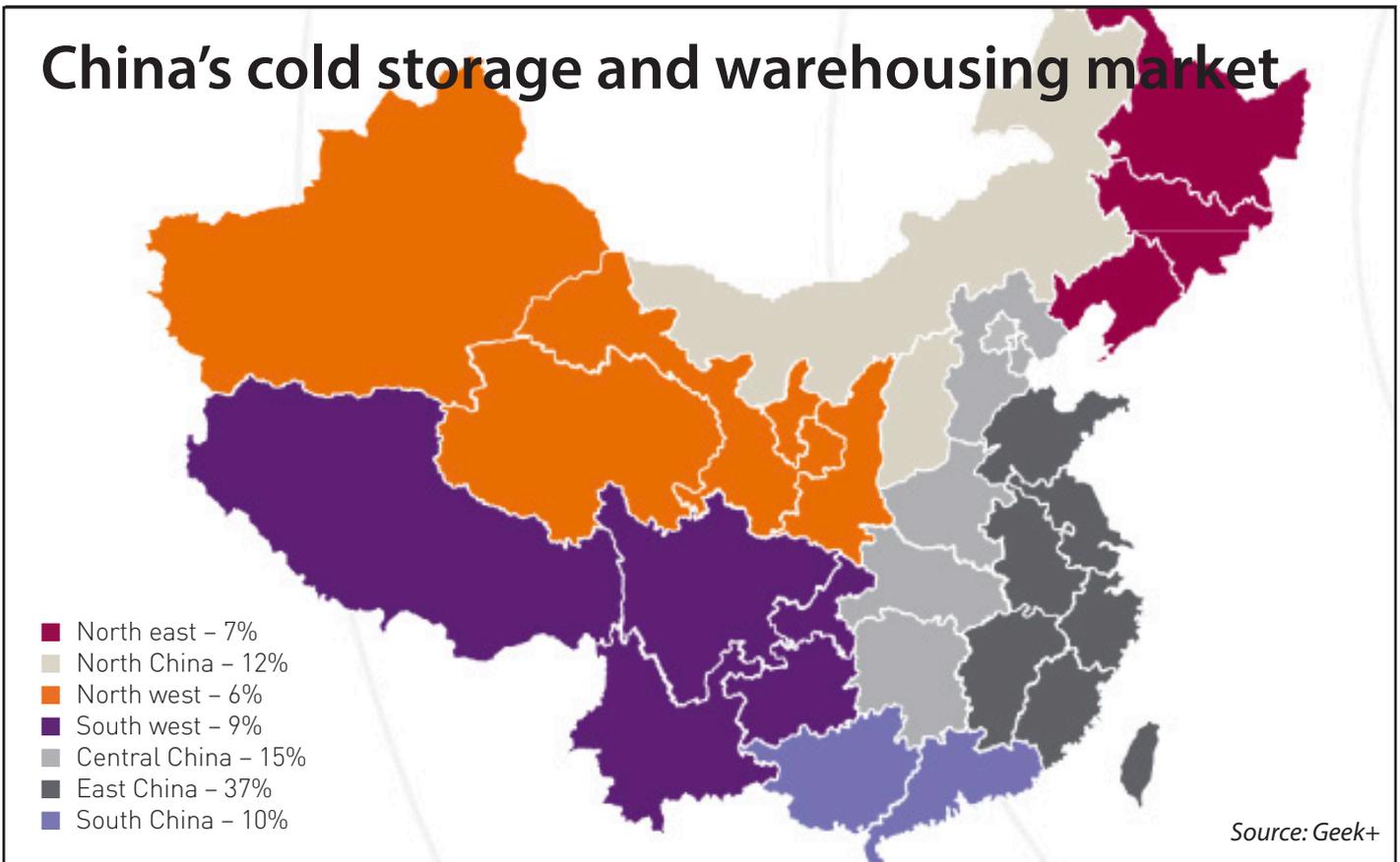


temperature required to preserve its freshness and quality throughout – from farm and production, through processing and packaging, to final delivery to retail outlet or even end customer.

A lot of these “cold chains”, as they are called, are relatively new. Until now, it was only the large, multinational grocers, for example, that could create a cold chain for their needs – transport perishables such as food, beverages, pharmaceuticals, flowers and so on – from one side of the world to another while maintaining its quality.

Many of these large multinationals gained much marketing value from showing that they could buy farm produce from Africa and have it on the shelves in Europe within 24 hours. Now, third-party logistics companies are providing smaller manufacturers and retailers cold chain networks that are helping them compete. And they need to have access to cold chains because consumers now take it for granted that products – whether they are perishable or not – can be moved around the world. That they are perishable and need to be kept in temperature-controlled environments is of little or no interest to the average consumer.

Another new development is in the area of regulation. Governments and their agencies are regulating more extensively, in more detail, and demanding more from production and supply chains – particularly for perishables.



And because of ever-increasing globalisation, regulations and standards are fairly similar across many countries around the world, particularly the leading economies.

This can also have an effect on how perishables are packaged. So, logistics companies are using packaging that has more insulation, enabling products to maintain their temperature even outside a refrigerated vehicle or cold warehouse. Ice packs are commonly used, and reusable and recyclable is increasingly preferred.

So, many types of innovations are taking place all along the supply chain to enable a temperature-controlled environment, and they will probably drive even more growth in already large markets, such as:

- fruit and vegetables;
- pharmaceuticals and medical products;
- wine and beverages;
- ice cream and frozen foods; and
- meat, poultry and dairy products.

In China, there is a significant trend towards developing cold chain technologies, with an emphasis on storage and warehousing. One of the key shifts is the move away from quantity to quality. There, optimal cold storage temperatures range from -25°C to approximately 25°C , with the strongest

Geek+ P series robot for low temperature work



Features

- Dimensions: 1040 mm x 820 mm x 280 mm
- Weight: 240 kg
- Payload capacity: 800 kg
- Lifting height: 60 mm
- Lifting time: 10 seconds
- Speed: 2 metres per second with no load, 1.5 m/s with load
- Lifting height: 60 mm
- Operational temperature range: -30°C to 50°C

Source: Geek+

demand seen in the -18°C to 4°C range. This is something Geek+ Robotics is studying, along with its partners, and introducing guidelines on how to build fully automated cold warehousing and storage facilities.

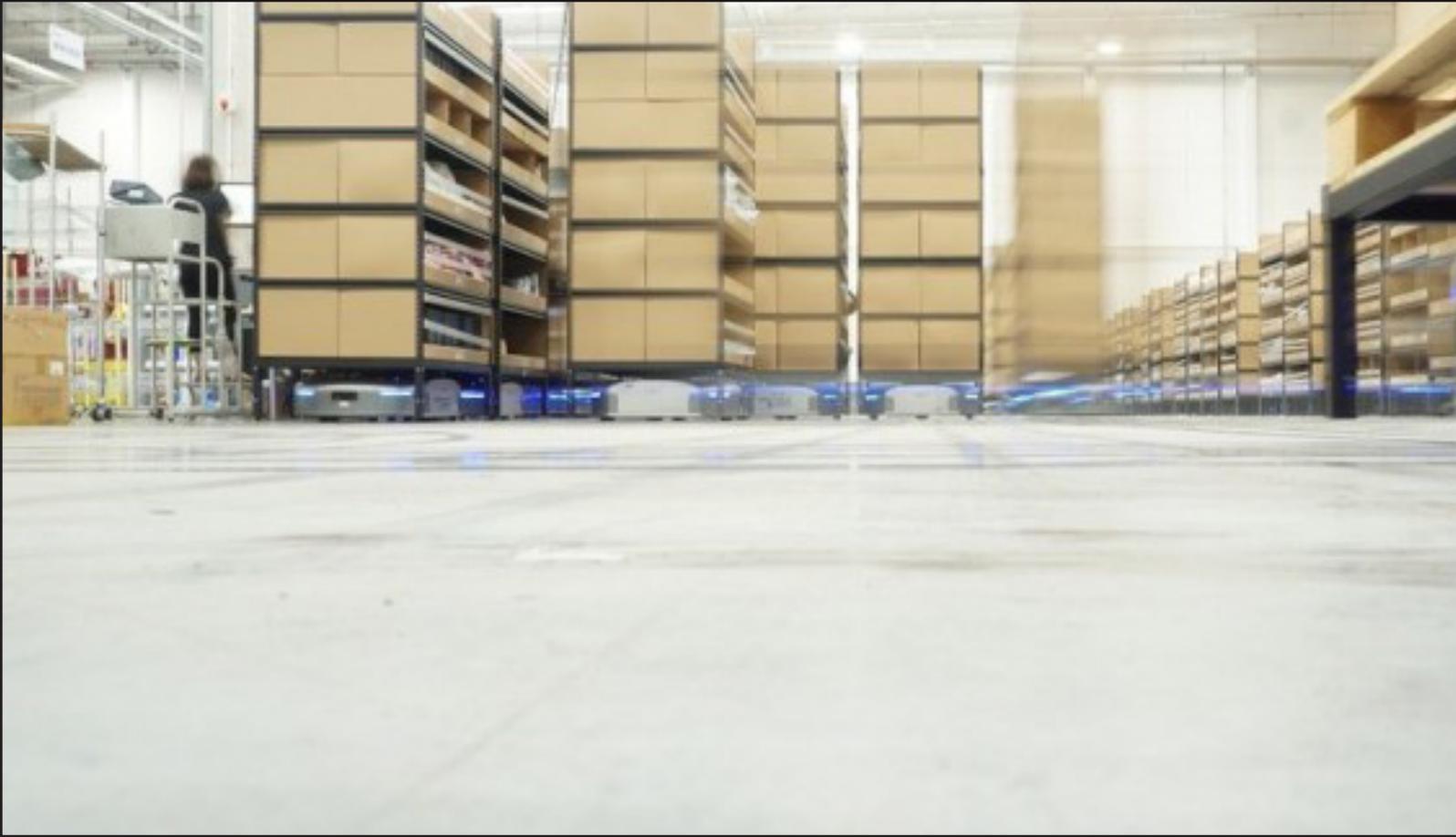
Among the technologies Geek+ is highlighting are steel structures, applied RFID, computerised transportation and order management systems, much of which centres on the warehouse robots the company manufactures and supplies.

The company has developed a robot that is specially adapted “low-temperature version” of its P series robot, which uses a low-temperature battery and other components. The robot’s circuit boards and sensors specially designed to operate in lower temperatures, which means it can operate at well below freezing, or zero, temperatures.

Geek+ says the availability of cold storage in China is unevenly spread geographically, and while there is significant capacity for fish and meat, the number of cold storage facilities suitable for fruit and vegetables is “far less than market demand”.

Geek+ also found factors which hampered the growth of cold chain in China. Specifically, the inadequate protective clothing for workers, and the risk of leakage of refrigerant. These factors make the management of cold storage facilities difficult.

However, work is being done to rectify the situation. ■



Regulations and robots would help cold chain

A study by Geek+ Robotics into the cold chain market in China revealed a number of interesting and perhaps alarming findings which could prompt more regulation of the industry, which, in turn, could help it to grow as fast as cold chain sectors in other countries are growing.

China's neighbour, India, currently has the fastest-growing cold chain market in the world, showing more than 40 per cent annual increase. China, meanwhile, has some issues it could address before its market also takes off.

The main concern Geek+ has expressed is the lack of protection for workers in the cold chain sector. When you are asked to work in below-freezing temperatures for prolonged periods, it need not take a genius to point out that your health is likely to suffer. So, as Geek+ has found, workers in the cold chain industry in China are often ill and need to take days off, causing disruption to companies and health concerns for individuals.



Clearly, adequately insulated or protective clothing could be one solution, and could be encouraged by government through regulation. China did sign an agreement with the US 10 years ago on cold chain standards, but it centred on the product – quality, freshness and so on – not the process or people working in the sector. Nonetheless, China adopted or developed some 200 cold chain standards as a result of that agreement, so it does have a good foundation on which to build. But so far, there have been very few compulsory standards and enforcement is patchy at best.

Another solution to the hazards of working in the cold chain industry is, of course, automation. Robots are often used for dull, dirty and dangerous jobs. In this instance, it could be said that working in the cold chain industry comes under the category of dangerous.

According to China's National Development and Reform Commission, revenue from cold chain logistics reached \$3.5 trillion in 2016, so it's not an insignificant part of the economy, and the number of people working in the industry must number in the hundreds of thousands if not millions.

The Geek+ P series robot was especially designed for cold chain operations, and is gradually finding its way into a number of different companies' warehouses. Its specifications include:

- Dimensions: 1040 mm x 820 mm x 280 mm
- Weight: 240 kg
- Payload capacity: 800 kg
- Lifting height: 60 mm
- Lifting time: 10 seconds
- Speed: 2 metres per second with no load, 1.5 m/s with load
- Lifting height: 60 mm
- Operational temperature range: -30°C to 50°C

One of the key things that Geek+ recommends is training – teaching people about the safety considerations and best practices when working in the cold chain industry. The company says this is not adequately done by many companies and it's something that is required.

Geek+ provides training on how to use its robots, and provides custom services relating to how to install and implement a robotic system in a cold warehouse and storage facility.

And perhaps that is the answer ultimately – robotics. It's difficult enough trying to persuade people to apply for and stay in jobs within the logistics industry in general, let alone the cold chain specifically. Perhaps the introduction of robotics into the cold chain market will minimise the need for humans to work in sub-zero temperatures and risk their health or at least forego their interest in less uncomfortable jobs. ■



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