

## LOGISTICS PROCESSES AND CHALLENGES IN AIR TRANSPORT OF TEMPERATURE-CONTROLLED GOODS

Sara Jovanović <sup>a</sup>, Ivana Ivanović <sup>a,\*</sup>

<sup>a</sup> University of Belgrade, Faculty of Transport and Traffic Engineering, Serbia

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**Abstract:** *The two basic parameters that determine the choice of mode of transport are the type of goods and the speed at which they must be transported. Despite the high costs and space constraints, the transport of goods by air is becoming an increasingly common choice of customers. This paper emphasizes the transport of perishable goods by air, which requires maintaining an appropriate temperature level in order to maintain good quality of the goods. Efficient implementation of all logistics processes and their continuous monitoring and control affect the success of the transport of this type of goods. The aim of this paper is to point out possible problems when transporting goods by air and the advantages of using different types of cargo handling units, which greatly facilitate the maintenance of the required temperature level, as well as conditions and recommendations for their transport by air.*

**Keywords:** *supply chain, logistical challenges, temperature regime.*

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### 1. INTRODUCTION

The growth of global trade over the last few decades has led to innovations that have made significant changes in business, primarily in equipment and infrastructure in warehousing, handling and transportation of cargo. Due to its speed and safety, air transport is becoming more and more present, especially when transporting cargo that requires special temperature regimes. It showed its importance to a large extent during the Covid-19 pandemic when a large number of medical devices and equipment, drugs and vaccines were transported by this mode of transport.

This paper consists of three parts and is organized as follows. The first section of the paper defines the cold supply chain, what it represents and what its requirements are, and then gives a brief overview of the groups of goods that are usually transported as well as the required temperature regimes for transporting each of them. After that, the types of cargo handling units that meet the requirements in terms of standards and regulations for the transport of goods under temperature regime, the so-called unit load device (hereinafter ULD), IATA (The International Air Transport Association) and their marking system, as

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\* ivanaivanovic1510@gmail.com

well as ULD identification codes and aircraft types in use, are described. Due to the specifics of goods under the temperature regime, there are a large number of different requirements in terms of logistics processes (primarily processes of storage, handling, packaging, transport, monitoring and traceability), which are described in detail in another chapter. The last chapter presents an example from practice, i.e., the challenges that the company Milšped (Belgrade) faces when organizing the transport of pharmaceutical products, which in the previous period due to the Covid-19 pandemic were the most common representatives of goods under temperature regime. Each challenge is accompanied by the way in which the company Milšped solves potential problems, and at the very end, the conditions and recommendations for the transport of these products are given.

## 2. COLD SUPPLE CHAIN

With a better standard of living, especially in the developed countries of the world, people are more aware of the quality and need to purchase products that are fresh and available only in certain parts of the world. These products can be called perishable goods, which includes all goods that will spoil or lose their quality during a certain period of time if they are exposed to unfavorable temperature, humidity or other environmental conditions. The growing need for the safe transport of products sensitive to temperature changes over long distances has led to the emergence of cold chain logistics. A cold chain is a temperature-controlled supply chain consisting of refrigeration plants for production, storage and distribution supported by equipment that can constantly maintain the required range of low temperatures to ensure the quality and functions it has (Menon, 2021).

### 2.1. Types of goods and their temperature regimes during transport

Depending on the type of products transported through the cold chain, specific temperature standards apply. For products such as fruits and vegetables, breach of integrity can lead to damage such as softening, bruising, unwanted ripening, discoloration, texture degradation as well as the development of rot and mold. When it comes to pharmaceutical and medical products, the inappropriate temperature can lead to loss of function and make these products unsafe to use. Although the optimal transport temperature varies from product to product, 5 basic temperature standards have been identified that are most commonly used (Figure 1) (Transportgeography, 2022).

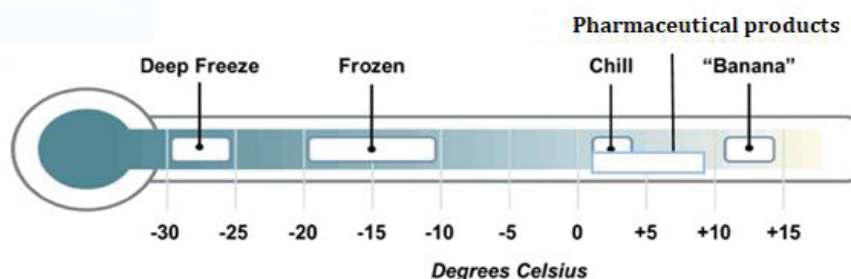


Figure 1. Basic temperature standards (Transportgeography, 2022)

Table 1 shows the types of goods transported under the temperature regime.

Table 1. Temperature range for transport of certain types of goods (Transportgeography, 2022)

<b>Temperature range</b>	<b>Type of goods transported under the specified temperature range</b>
<b>Deep freezing (-30 to -25)</b>	<ol style="list-style-type: none"> <li>1. Seafood (especially shrimp)</li> <li>2. Ice cream</li> </ol>
<b>Frozen (from -20 to -10)</b>	<ol style="list-style-type: none"> <li>1. Frozen meat (beef, pork, poultry)</li> <li>1. Frozen bakery products (cakes, bread, etc.)</li> </ol>
<b>Chilled (from 2 to 4)</b>	<ol style="list-style-type: none"> <li>1. Fruit</li> <li>2. Vegetables</li> <li>3. Fresh meat</li> </ol>
<b>Cooling (from 2 to 8)</b>	<ol style="list-style-type: none"> <li>1. Pharmaceutical products (drugs, vaccines)</li> <li>2. Medical products</li> </ol>
<b>Chilled (from 12 to 14)</b>	<ol style="list-style-type: none"> <li>1. Fruits - whose ripening is controlled during transport, most tropical fruits such as bananas, oranges, pineapples, etc.</li> </ol>
<b>Temperature ranges from 15 to 25</b>	<ol style="list-style-type: none"> <li>1. Flowers</li> <li>2. Certain pharmaceutical products such as various types of vitamins</li> </ol>

## 2.2. Types of aircrafts and ULDs when transporting goods under temperature regime

In the cold chain, time is of the essence to ensure that products arrive at their destination while still offering maximum quality and shelf life. As a result, many of these goods are now transported by air. Passenger and cargo aircraft are used for transportation. Passenger aircraft are generally more frequent, cheaper and more accessible, which are also the main reasons for their use for freight transport. Cargo aircraft are specially designed for the transport of various cargoes and, accordingly, enable better temperature control, additional capacities and smaller inspections. On the other hand, the flight schedule is much rarer compared to passenger flights, they provide a smaller choice of locations, are more expensive and often wait for filling capacity to start the flight, which is extremely unfavorable for perishable and sensitive goods (Baxter and Kourousis, 2015).

ULDs are very often used for the transport of goods under a temperature regime. ULD is a cargo handling unit for grouping and retaining cargo in air transport. It is designed to be directly attached by a cargo loading system to the aircraft and thus becomes part of the aircraft structure during flight. The design largely depends on the purpose, and the type of aircraft in use (whether they are wide-body or narrow-body). They can be certified or not. Certified ULD is one that is considered an integral part of the aircraft, corresponds to the fastening systems in the aircraft, and is structurally designed to ensure i.e., strengthens the cargo and thus protects the structure of the aircraft and other fastening

systems from damage. Certified ULD has approval, issued by the state agency responsible for aviation, which confirms to the manufacturer that ULD meets all the safety requirements of the aircraft in which it should be transported. While non-certified ULDs can only be loaded into an aircraft compartment with certified cargo securing systems, in accordance with the aircraft manufacturer's instructions and weight limits (Jovanović, 2017).

When transporting goods under a temperature regime, ULDs can be used in 2 ways:

Standard ULD whereby the goods must be packed in an appropriate manner in various specialized packages with the possession of dry ice or gels to maintain the temperature of the product during transport, liquid nitrogen, eutectic plates and insulation covers. In this way, ULDs provide protection against damage during handling, facilitate loading and unloading and make it faster, and protect goods from atmospheric precipitation, while proper packaging maintains the desired temperature (Baxter and Kourousis, 2015).

Refrigerated ULDs allow the desired temperature to be maintained within the load unit itself, these containers operate using an active temperature-controlled system based on compressors, refrigeration or electric heating equipment. These containers also have an insulated shell that helps maintain the proper temperature during the transport cycle, while the temperature can be checked and monitored at any time with the help of innovations such as RFID, and also the condition of the battery can be checked at any time. The temperature range varies from -20 to +25°C according to the type of goods being transported. It is also possible to work on rechargeable batteries, which can last about 35 hours and can be charged in a standard AC outlet (Baxter and Kourousis, 2015).

One of the options during transport is that the aircraft itself has the ability to achieve a certain temperature regime with the help of various cooling devices and systems. At the same time, a very important thing is the altitude at which the aircraft flies. The higher the flight altitudes, the lower the temperatures, and thus the internal temperature in the aircraft can be disturbed and, in that way, damage the goods being transported. For these reasons, it is recommended that when transporting goods under a temperature regime, flights at lower altitudes should be realized (Baxter and Kourousis, 2015).

Chapter 17 of the IATA Perishable Goods Ordinance entitled "Air Transport Logistics for Time and Temperature Sensitive Health Care Products" specifically addresses the issues of temperature control management identified by industries. The chapter describes in detail the requirements and standards for the transport of weather and temperature-sensitive medical air cargo shipments, including the mandatory use of the Time and Temperature Sensitive mark which must be affixed to all shipments reserved as time and temperature-sensitive cargo. It has been in force since July 1, 2012 (Baxter and Kourousis, 2015).

ULDs must have a valid three-letter IATA ULD marking system (Jovanović, 2017):

- First letter (position 1): ULD category (whether certified; part of the structure or not; whether there is equipment for cooling, insulation or temperature control; what type of ULD is in question: pallet, container, net, needle),
- Second letter (position 2): base dimensions,
- Third letter (position 3): ULD contour and compatibility with loading and securing equipment (e.g., if "N" then it can be manipulated with a forklift).

In addition to this, IATA also has its own identification codes for ULDs, which consist of 9 or 10 elements, which are arranged as follows (Jovanović, 2017):

- Positions 1-3: basic nomenclature of ULD (category, base dimensions and contours/compatibility),
- Positions 4-7 (8): ULD serial number, consisting of four or five digits,
- The last two positions: the alphanumeric designation of the ULD owner.

### 3. LOGISTICS PROCESSES IN THE COLD CHAIN

There are countless requirements that need to be met in order for the logistical processes (storage, packaging, transport, handling, etc.) for goods under temperature regime in air traffic to take place properly. Each type of goods that is under the temperature regime has its own specifics and accordingly different requirements. Some of these requirements, observing the logistics processes, are explained in more detail below.

**Storage** - Most of the cargo delivered to the airport does not stay long. Related to this is the fact that a large number of warehouses are quite simple and provide simple services, especially when it comes to less frequent airports or which are classified as an alternative in a country. Newer generation airports with modern warehouses have loading stations (ramps) in order to speed up the process of truck movement and minimize the time of unloading goods, after which the goods are sent for further security checks and procedures. Warehouses are always divided into parts intended for goods to be exported (where there are large areas for scanning, an inspection of goods, palletization and collecting cargo for certain flights) and goods imported into the country (where there are offices and premises for inspection reviews, in order to facilitate customs clearance procedures and separate cargoes and their loading on trucks). Perishable goods require specific conditions in the warehousing sector as well. The warehouses where this type of goods is located are under constant supervision and with the appropriate temperature regime in order to maintain a cold chain between the truck and the aircraft. This allows exporters to store perishable items for as long as possible in the event of a flight delay or if they miss the shipment for some reason (The World Bank Group, 2009).

**Manipulation** - Cargo handling operations at airports include preparation of cargo shipments, loading and unloading of aircraft, and cargo transfer between warehousing and land transport. Outgoing cargo preparation includes cargo consolidation, pallet and container preparation, inspection and documentation. The goods are placed on pallets and in ULD containers before loading into the aircraft, in order to facilitate the procedure. Preparations for the importing load include customs and other regulatory procedures, as well as deconsolidation. For goods that are classified as perishable goods, it is necessary to provide refrigerators, i.e., rooms where the temperature will be maintained in accordance with the requirements of the delivered cargo. The inspection is mainly performed at the airport, including scanning, visual and other checks. Personnel in charge of cargo handling at the airport should ensure that the processes are carried out efficiently and safely so that there are no changes in the goods in relation to the condition in which they were received (The World Bank Group, 2009).

**Packing** - in order for the goods to reach the airport safely, continue their journey by air, and then be transported to the end-user, it is necessary to be properly packed in accordance with their characteristics. The type of goods determines the type of packaging to be used. In that sense, the packaging must provide adequate protection for the products

inside it and prevent their possible degradation. For the purpose of ensuring and preserving the quality of the product, it is sometimes required that the product has both inner and outer packaging, in order to prevent contamination and spoilage of the product caused by external factors (sunlight, moisture, heat, insects, etc.). For example, some countries require a fine plastic net that is placed over a pallet as an external lining to prevent pests. They are used for fruits, vegetables and flowers. The second type is polymer foils wrapped around the pallet to protect the shipment from moisture and prevent leakage if the products are liquid or with a high percentage of water in their composition (Vietnam Airlines and IATA, 2022).

Common packaging for perishable goods used in air transport includes (IATA, 2022):

1. Fiberboard packaging,
2. Expanded polystyrene (EPS) packages,
3. Solid plastic packaging,
4. Flexible plastic packaging,
5. Packages for vacuum and modified atmosphere,
6. Wooden packaging,
7. Metal cans and canisters.

After the packaging is selected, in order to maintain the temperature level according to the requirements of the goods that are the subject of transport, it is necessary to use a refrigeration device or special refrigerated containers that are specifically designed for this purpose. Thanks to them, the goods remain unchanged in condition, shape and quality.

**Transport** - during transport it is of great importance to know what type of goods is transported, and then what conditions and equipment are required during transport. Most refrigerated, semi-refrigerated and fresh products are stored and transported at temperatures between  $-1.5^{\circ}\text{C}$  and  $+14^{\circ}\text{C}$ , depending on the type of product. However, the products can be transported even if they are completely frozen. Perishable products such as flowers, fruits and vegetables can easily transfer their scent from one product to another, that is, contaminate the products in their vicinity, as is the case with vegetables and fruits that contain high levels of ethylene and affect their mature too quickly and thus endanger other goods (LTU International Airways, 2012).

For this reason, various specialized packaging is used for these products that belong to the group of perishable, as well as refrigeration devices, dry ice or gels to maintain the temperature of the product during transport. Dry ice is used to transport frozen fruits (such as berries), frozen vegetables, as well as food samples (various types of pastries). In addition to food, dry ice is also used for the transport of sets of COVID tests, as well as for some reagents, drugs and certain chemicals that are an integral part of medical devices. Another method of transporting goods sensitive to temperature changes is using thermogels (Figure 2). In contrast to dry ice, thermal gels are not treated as dangerous goods, but they are a more expensive solution, and they are packaged as a liquid refrigerant that absorbs heat and maintains a constant temperature. Liquid nitrogen is also used, which is used primarily for the transport of biological cargo (organs, tissues). It is extremely cold, it keeps items frozen for a long time. Eutectic plates are also called cold plates, similar to gel packs, but they can be reused, which is their advantage (Heap, 2006).



Figure 2. Packaging of goods a) gel b) dry ice (FedEx, 2019)

**Monitoring and traceability** – pharmaceutical companies, restaurants and retail food chains go in the direction of adopting visibility monitoring solutions in order to gain visibility and control in the entire supply chain. Data on delivery, location, data on records and traceability of the cold chain are easily accessible and very important because they provide immediate insight into the movement of goods, the condition of goods during transport and their location. The existence of software that determines exactly where the cargo is at all times and the ability to access this information via mobile phone or computer speaks of technological progress and is crucial for the next generation of services to be provided. Built-in sensors, including light, temperature and barometric conditions, monitor the condition of the product during its journey, triggering an alert if certain errors appear on your computer or mobile phone. GPS tracking allows stakeholders to know when products have left the warehouse and when they have arrived at their final destination. Therefore, logistics providers are increasingly investing in meeting visibility requirements. The number of points of contact is increasing, and knowledge of what is happening at each of these points of contact strengthens data for stakeholders to mitigate risk, improve logistical performance and standardize their metrics (Rodrigue and Notteboom, 2016).

#### 4. CHALLENGES IN THE TRANSPORT OF GOODS UNDER TEMPERATURE REGIME - EXAMPLE OF THE COMPANY MILŠPED BELGRADE

Through a wide network of agents, Milšped is present at commercial airports in over 150 countries around the world, making sure that customers' delivery, routing and handling requirements are met. The range of products for which they organize import or export is very wide. The goods that stand out the most when importing and exporting, and also belong to the temperature-controlled goods are pharmaceutical products. Some shipments of pharmaceutical products must be delivered within certain time frames in order to protect their value. Others are fragile products and require special handling.

The most often problems that occur during air transport are the following:

- **Improper storage temperature**- before bringing the goods into the warehouse, it is necessary to determine the appropriate temperature for the same. According to the words of the manager N. Kolundžija, first, it is defined which pharmaceutical products are in question, whether they are drugs that are stored at temperatures

from 2 to 8°C. Vitamins are stored at relatively higher temperatures. Accordingly, the place in the warehouse is agreed upon, whether it will be some remote positions where the temperature is lower than in other parts of the warehouse, or it will be necessary to put the goods in the appropriate refrigerators.

- **Discontinuous use of transport equipment** - the consignor may try to reduce costs by avoiding temperature control on less critical journeys, which is completely unacceptable for this type of goods that require continuous cooling, especially on parts of the road where outside temperatures are high (Heap, 2006).
- **Loading problems** - during loading, a larger number of units is usually brought in than must be loaded into the aircraft at once. In this way, one part of the shipment remains directly exposed to atmospheric influences. In order to prevent the deterioration of this product, it is necessary to protect the units from direct impact by covering them with blankets (insulated quilts can be wrapped or placed over the load and used to maintain a constant temperature, so that frozen items will remain frozen for a long time). Also, there is a problem that the goods are stored earlier than necessary and then waits for loading, where it is again exposed to the mentioned conditions. It is necessary to draw the attention of the warehouse workers to the goods in question in order to avoid unnecessary situations that could be dangerous to the quality of the goods.
- **Packaging errors**- they are very rare for goods that require a temperature regime, while they are very common for general cargo. However, before placing the goods in storage, it is necessary to check whether the packaging is appropriate and whether all regulations and recommendations have been followed (Heap, 2006).
- **Flight cancellation** - flights can be canceled for various reasons (failure, weather conditions, etc.) and in that case shipments that are under temperature regime suffer the greatest consequences, both due to the short lifespan and the inability to maintain the required temperature at the airport until conditions are met for shipping goods. The costs caused by these problems are extremely high. This problem is sometimes unavoidable when it comes to weather problems, but the technical correctness of the aircraft and its crucial parts is something that can be influenced through continuous checks and tests before the aircraft takes off.
- **Delivery Delay** - related to the previous problem, in the case of connecting flights, there may be delays, and thus the delivery of goods will be after a defined time, which again entails high costs. These problems can be mainly influenced, since they are a consequence of delays in operations that precede the transport itself - checking and completing documentation, loading and all other manipulative activities. Constant monitoring of the execution of these operations creates the conditions for these activities to be performed on time and in that way to avoid all possible delays.

When it comes to the conditions and recommendations for the transport of pharmaceutical products by air, the following stand out (Hyde, 2020).

Falling demand for air cargo and combined passengers is leading to two problems for the pharmaceutical industry. As air cargo space becomes even more valuable and a dwindling resource, there are measures that can be applied to mitigate reduced capacity. For example, temperature-controlled packaging systems should be at the forefront to reduce



bulk density, providing better insulation performance and materials that can significantly improve volumetric efficiency. However, packaging systems currently available to reduce bulk density are usually more expensive unless reused, which cannot always be effectively achieved for both financial and environmental reasons. The pharmaceutical packaging industry should carefully consider the installed capabilities of aircraft to control temperature, which could make lower quality packaging materials more acceptable. Aircraft facilities also need to be synchronized with the conditions on the ground, and this can be a problem in less developed regions of the world. When it comes to pharmaceutical packaging, one size does not suit everyone - nor should it. Packaging manufacturers are expanding their product portfolios to enable the selection, qualification and application of the most efficient solutions in global supply chains. Making the right choices and performing the necessary qualifications can be difficult, but this is a challenge that needs to be faced in order to responsibly use dwindling resources. This can be a problem in less developed regions of the world. One of the most important recommendations is that pharmaceutical products in air transport should be marked with regular labels for pharmaceuticals (PIL - Pharmaceutical products), and not perishable products (PER - Perishable), in order to properly manipulate them and avoid problems in communication.

**Standardization** - In order to ensure efficient management of pharmaceutical products, it is necessary to have appropriate standards that will facilitate business for all participants in the chain. Working with stakeholders and regulators in the aerospace industry, IATA has created the Center of Excellence for Independent Validators in Pharmaceutical Logistics (CEIV Pharma) to help organizations and the entire air cargo supply chain get on the right track to excel in pharmaceutical handling. CEIV Pharma addresses the needs of the industry for safety, security, compliance and efficiency, by creating a globally consistent and recognized certificate for the handling of pharmaceutical products. By establishing a common basis based on existing regulations and standards, this certification ensures international and national compliance in order to preserve the integrity of the product, while addressing the specific needs of air cargo (Milšped, 2022).

## 5. CONCLUSION

Based on what has been said so far, it is clear that among the numerous requirements that need to be met, when it comes to transporting goods under temperature regime by air, the main ones which stand out are providing appropriate technology, which with its advanced systems will support the implementation of this and all other processes arising from the transport of goods; training of employees and their understanding of the importance of the positions they hold and the jobs they perform at the level of the entire supply chain; and finally - standardization, which is the basis for solving all the problems caused by irregular business practices and at the same time and opportunity to balance such processes. Transporting products under a temperature regime is a challenge for the airlines that accept them for transport, considering that transport can also be viewed as a phase in which the goods behave as if they were in a warehouse. By applying newer solutions, such as special refrigerated containers, individual refrigeration devices and materials used to maintain the required temperature level, the environment in the aircraft is successfully simulated in which the goods remain unchanged and quality. In this paper, challenges with which the participants in the realization of the process can face, were observed. The focus is on planning and implementing these processes and ways to

overcome the problems that arise, while respecting all the conditions set by the goods with their characteristics, on the one hand, and airlines that have their own requirements and are responsible for shipments during transport, on the other hand. As there is always a need to go in the direction of finding better solutions compared to existing ones, airlines will constantly strive for optimal implementation of all logistics processes (from warehousing, handling, all the way to monitoring) and the application of new technological solutions that will adequately respond to the set and increasingly complex requests of clients. What is certain is that preserving the quality and integrity of goods will always be an imperative for all participants in the supply chain, no matter with what mode of transport goods are being transported.

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