

## Temperature Control for Regional Transport

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**Abstract:** The introduction of this article outlines the terms and conditions of food control in the Slovak Republic and the institutions that provide it. This section also provides the comparison of inspection results in selected periods. The second part of the paper describes the measurement of the regional transport of perishable food products. The measurement compares all permitted temperature tolerances and is subsequently evaluated. The results of the measurements are also compared with the analysis of the number of checks carried out.

**Keywords:** Food, transportation, measurement, control

### 1. Introduction

When transporting food, it is important to keep food at the prescribed temperature and humidity throughout the whole supply chain. This is constantly partially adjusted and regulated by the legislation and the system of compliance checks of these conditions changes in each country as well.

The paper analyzes the transport of dairy products from the central warehouse to retail outlets. In this part of the supply chain, the most common occurrence is failure to comply with conditions either during handling or shipping. Vehicles on these shipments are often not certified according to the ATP Convention, and handling sites are not adapted for these types of food.

### 2. Data and Methods

Food inspection during transport must be carried out as a precaution against changes in temperature and humidity that can adversely affect the quality of the food. The temperature must be compared with the existing temperature conditions and also with the sender's requirements who must accurately determine these temperatures. In this measurement, the requirements of the ATP Convention [1] were compared with sender's requirements and with real measured values.

## **2.1 Food Inspection in the Slovak Republic**

The bodies of the State Veterinary and Food Administration of the Slovak Republic [2] control the production, trade, handling and marketing of food. In its information system, the Administration gathers information on operators, official food inspection findings, completed administrative procedures based on the results of official food inspection.

The Administration is entitled to use data from the information system to guide, manage and coordinate the official inspection of food and to inform the public about dangerous food and to publish the lawful decisions on its web portal within three months from the date of their entry into force. Food inspection authorities ensure that their activities are carried out with a high level of transparency and, to this end, disclose relevant information relating to inspection activities and their effectiveness. Within their scope, they also impose measures and fines and discuss violations they find when carrying out official inspections.

### **2.1.1 Sampling**

During the inspection, selected types of temperature measuring containers must be such that their temperature is at the warmest point of the shipment. If samples are to be selected during unloading, four should be taken from the top and the consignments adjacent to the edge of the door opening should be selected from the bottom. If sampling is carried out during the unloading of the consignment, the samples should also be taken from the top back corners of the consignment, from the center of the consignment, or from the top or bottom of the consignment fronts [3].

Allowed tolerances during temperature measurements are [4]:

- Operational - In the case of frozen foods or quick-frozen foods, a short temperature rise of up to 3 ° C to the temperature set out in Annex 2 to the ATP Agreement is permitted for the surface temperature of the food.
- Methodological - non-destructive measurement can allow for temperature tolerance max. by 2 ° C after comparing the reading temperature to the actual measured product temperature, particularly with respect to the thickness of the package plates. This tolerance is not used for destructive measurements.

During transportation, non-destructive measurements shall be made after loading into the vehicle and the results shall be recorded in the accompanying documents. Destructive measurements are to be made when a problem occurs. If necessary, measurements can be performed directly during transportation. When selecting samples, non-destructive measurements should be performed first and it should only be decided on their basis whether destructive measurement will be carried out. A total tolerance of 2.8 ° C (2 ° C for process limitation and 0.8 ° C tolerance for system) is applied.

## 2.2 Food Handling During Transportation and Storage

Handling is essential when transporting food. This is especially relevant to loading and unloading of goods. When handling goods it is necessary to observe the same conditions as were set for the goods at the previous point in the refrigeration chain because that is where the greatest risk of not keeping food temperature and hygiene lies. Foods must be transported based on their type only in a designated and approved means of transport or vehicle [5,6].

Any temperature shock shortens food's shelf life. Therefore, it is very important that the prescribed temperature and humidity of the food are respected until the product reaches its end consumer. Wholesale chains are subject to strict hygiene control; their frequent audits usually lead to a proper provision of the temperature chain. The problem, however, occurs often when retailers buy the food from a wholesale warehouse at the right temperature, but during the transport to their retail store, restaurant, guesthouse, hotel, and so on this temperature fluctuates.

Therefore, it is necessary to follow the correct principles even when handling goods at any point in the refrigeration supply chain. It is imperative to use proper handling equipment and adhere to proper hygiene and temperature regimes [7].

## 2.3 Legislative Provision for the Transport of Dairy Products

Before the loading of refrigerated products, their vehicle transport space should be cooled, keeping the temperature constant during unloading. (CAC CRP 2004) [8].

Annex 3 of the ATP Agreement [1] states that the refrigerated foods must be transported in an designated vehicle which is to be used in such a way that the highest food temperature during transport at any point of the cargo does not exceed the specified temperature. In the case of dairy products, the temperature is as shown in Table 1.

**Table 1** Temperature of dairy products states in ATP Agreement. Source: [1]

Meat products, pasteurized milk, fresh dairy products (yoghurt, kefir, cream and fresh cheese), semi-finished products (meat, fish, vegetables), ready meals, fresh vegetables and vegetable and fish products not listed below	Either at 6°C or based on the prescribed temperature found on label or in transport documents	+7,2 °C	+3 °C
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## 2.4 Measurement Carried out During Food Products Transportation

In order to verify the possible critical points during food transport, measurements of loading area's internal temperature were carried out using a measuring device Testo Saveris [9].

The measurements were carried out a Citroen Berlingo vehicle with a distinguishing mark according to the ATP FNA-X. Agreement in the time period from 11.8.2017 to 19.8.2017. This period was chosen because of a prediction of a jump of outside temperature which was confirmed by further measurements. Therefore, it was possible to compare the change of the internal temperature in the vehicle's loading part at average temperatures of 28 ° C as well as at 15 ° C. The outside temperatures recorded by the driver are shown in Table 2.

**Table 2** The outside temperatures recorded by the driver are shown in Table 2. Source: authors

	6:00-10:00	10:00-
<b>10.8</b>	31	31
<b>11.8</b>	22	33
<b>14.8</b>	15.5	22
<b>15.8</b>	17.4	23.25
<b>16.8</b>	17,8	29
<b>17.8</b>	18.25	22.7
<b>18.8</b>	18	26.5

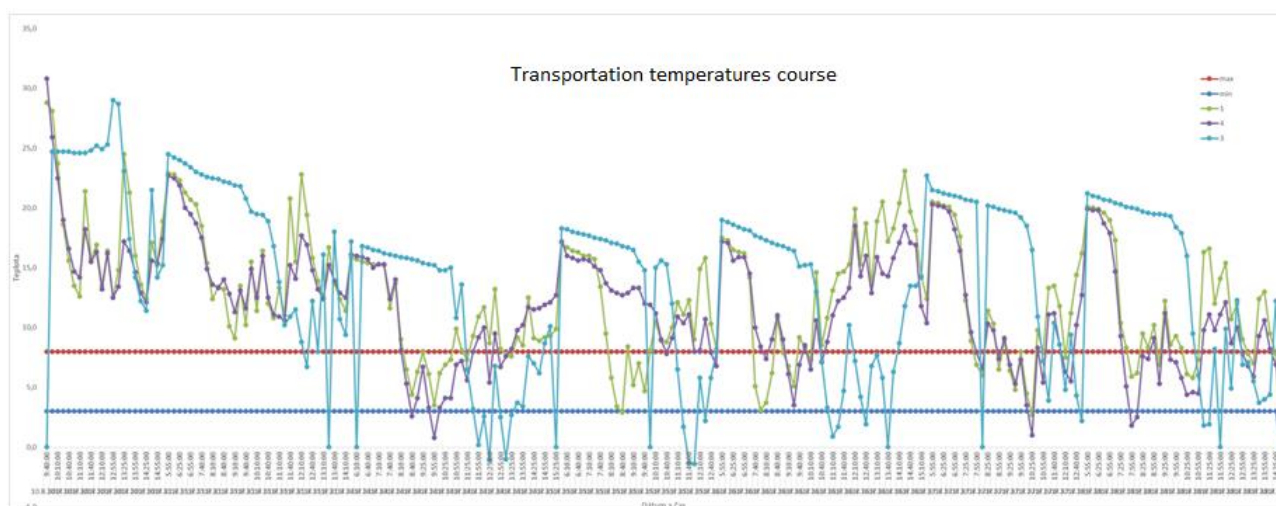
The outside temperature was detected by a sensor located directly on the vehicle and recorded from the vehicle's on-board unit.

Measurements inside the loading area were performed by Testo Saveris [9] measuring devices. These probes are calibrated for temperature measurements ranging from -20 to +50 ° C.

The probes were placed directly on the transport units because there are no guide rails in the vehicle to which they could be attached, and it is not possible to mount them on the wall as a result of the temperature and humidity in the vehicle.

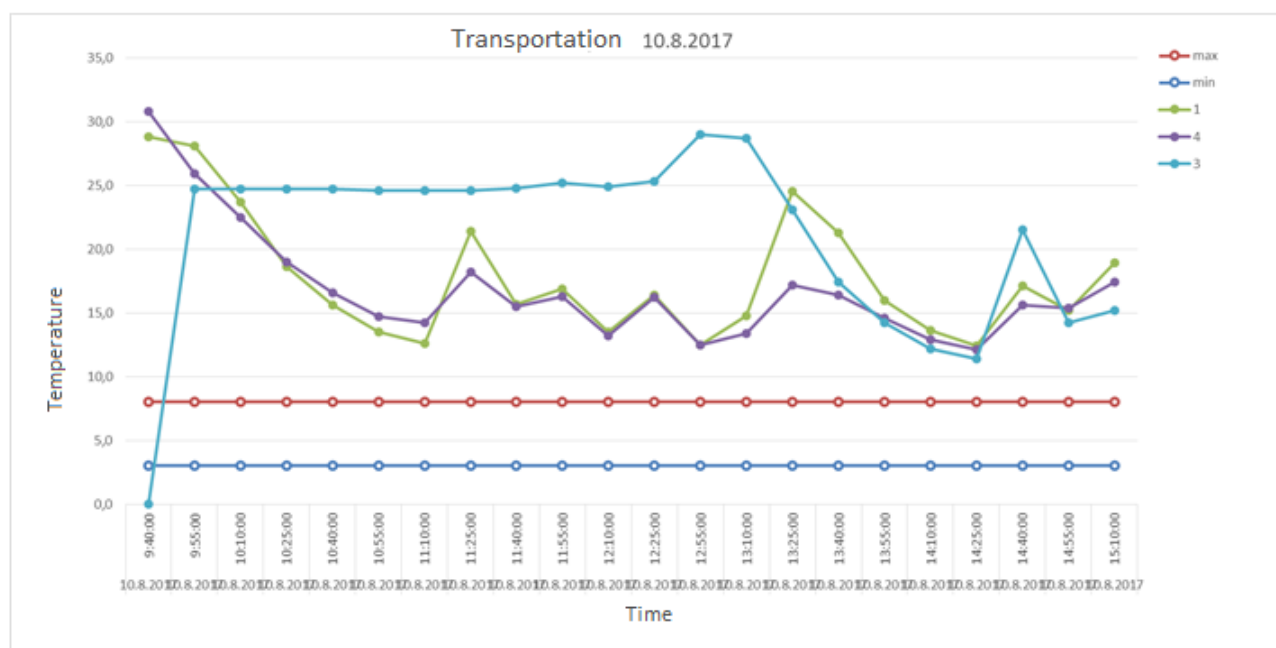
It pertains to food distribution, in this case the distribution of dairy products. The required transport temperature was between 3 ° C and 8 ° C. The delivery was carried out from the central warehouse around Žilina to the shops in Žilina region.

The problem with their unloading and handling is the failure to accommodate the unloading ramps to the good that require continuous temperature control. Some retailers lack ramps as well and handling is done only by a driver who must first manually place the goods outside and subsequently bring them into the store.



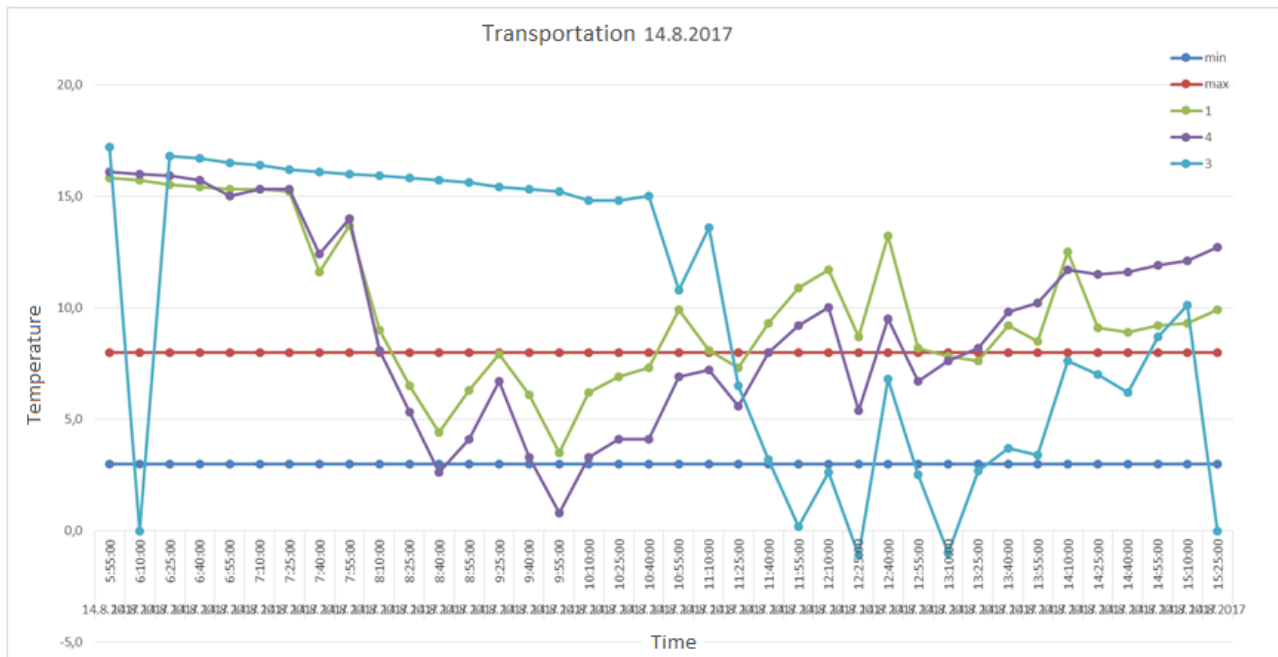
**Fig. 1** Graph of temperature of the whole measurement process. Source: authors

The resulting measured values are shown on Fig. 1. The red and blue colors indicate the minimum (blue) and maximum (red) transport temperature limits. It can be seen in the chart that on the first day of transport, when the outside temperature exceeded 31 ° C, the prescribed transport temperature was not maintained. The measurement graph from 10.8. is also shown in detail on Fig.2.



**Fig. 2** Graph of temperature from 10.8.2017. Source: authors

During the transportation on 14.8., the lowest outside temperature was recorded. From 6:00 am to 10:00 am, the average outdoor temperature was 15.5 ° C and from 10am till the moment of delivery the transport temperature was 22 ° C. On this day, as seen in Graph 1, the temperature stayed more within the range of the minimum and maximum required temperatures inside than outside. This can be seen in detail in Fig 3.



**Fig. 3** Graph of temperature from 14.8.2017. Source: authors

### 3. Results

#### 3.1 Results from Food Inspections

Each month a report is drawn up from the inspections with the statistics carried out both during operations and during transport. The Administration portals also contain the exact locations of the inspection, the date of the inspection, the inspection number, the inspected legal entity, the street, the municipality, the type of deficiency, the result of the inspection and the details of the inspection carried out. Also, the controls are displayed on an interactive map where you can search for individual controls, some of which are complemented by photographs.

Numbers in Table 3 were obtained after reading the data directly from the portal website. From this table it follows that the number of inspections during transport is very low compared to the number of inspections in the operations. Also, the number of inspections fell in 2013 and by as much as 1 As is seen from the table, the number of inspections during transport in the designated time period has decreased and reached only 3,39% in 2015 of the overall number of inspections. 0% compared to 2015 [10,11].

**Table 3** Comparison of the number of individual types of inspections from the internet website of the Portal of administrative inspections. Source: authors

<b>YEARS</b>	2013	2014	2015
<b>TOTAL</b>	50 617	55 406	50 490
<b>Operations</b>	43 795	52 310	48 780
<b>During transport</b>	6 822	3 096	1 710
<b>% in operations</b>	86.52 %	94.41%	96.61%
<b>% during transport</b>	13.48 %	5.59 %	3.39 %

### 3.2 Results from the Measurement

As can be seen in these measurements, when it comes to distribution tasks, the required transport temperature is maintained only in a very small number of cases. This is due to the failure to abide by the loading and unloading conditions and to choose the right type of transport vehicle [11-13].

At the start of the measurements, a control table filled with the driver was set in order to compare the external temperature during transport with the internal measured temperature. This is especially important for the distribution tasks where there is frequent opening of the transport space. Longer international shipments to these heat transfers occur at least in the absence of shipping space [12].

As can be seen from the measured values, the higher ambient temperature has a great effect on the change in the internal temperature. At higher outside temperatures, this will greatly affect the internal temperature. Conversely, at a lower temperature approaching the desired internal temperature, this is not affected. Therefore, it is very important to emphasize sufficient pre-cooling of the shipped commodity before loading. It is also important to ensure the functionality of the transshipment ramps and their presence at each transshipment point. This is inappropriate in the case of distribution tasks where most small retail have no ramps at all or only ramps with insufficient equipment [12,14-16].

## 4. Discussion

Therefore, as can be seen in Table 3, where the number of transport checks is displayed, this value should be increased so that carriers strive to get as close as possible to the required transport temperatures. Due to the failure to abide them, it can ultimately cause health problems for the final consumer. If temperature inspections became more frequent, carriers would demand retailers to improve unloading and handling conditions. An increased number of inspections should also take place in direct operations facilities [17,18].

## 5. Conclusion

From the point of view of the requirements of the ATP Agreement and EU food hygiene legislation, neglected transport conditions result in a risk of insufficient consumer health and safety. As the measurements show, the temperature of transported goods has not been kept; it is important to note that even a slight temperature change during transport of dairy products may degrade these goods.

This is often invisible at first sight and so the risks associated with mishandling of dairy products often remain unknown and unnoticed. Carriers should be more frequently and more thoroughly inspected by designated authorities. According to available statistics, however, the number of inspections is decreasing instead. These inspections should be carried out directly during transport, where the most common errors can be spotted and measured. Inspections should also be carried out in stores and operational facilities; emphasis should be placed on the conditions of ramps and areas of transshipment.

## References

- [1] UNECE. (2017). Agreement on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be Used for such Carriage (ATP), from <https://www.unece.org/trans/main/wp11/atp.html>. ISBN 978-92-1-139153-4.
- [2] Reports on official food control. (2017). from <http://www.svps.sk/potraviny/spravvy.asp>.
- [3] Manual, Food Metrology; Advising on the implementation of legislation on measuring instruments (in Slovak). (2017).
- [4] EUR-Lex. (2005). Commission Regulation (EC) No 37/2005 of 12 January 2005 on the monitoring of temperatures in the means of transport, warehousing and storage of quick-frozen foodstuffs intended for human consumption, from <http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32005R0037>.
- [5] Kerekréty, J. (2004). HACCP in practice. Hygiene rules in catering services according to the EU requirements (in Slovak), Publisher: Dr. Josef Raabe, s.r.o, o.z. ISBN 80-89182-01-1.
- [6] Anonymous. (1990). Guide to food transport: fish, meat and dairy products. Copenhagen: Mercantila Publishers, from <https://www.scribd.com/document/250337223/Guide-to-Food-Transport-Fish-Meat-and-Dairy-Products>.
- [7] Kubasáková, Kubáňová, J. & Poliaková, B. (2015). Modelling of opened system in the road freight transport and its impact characteristic I. Transport means 2015, (pp. 405-409). ISSN 1822-296X.



- [8] National Agricultural and Food Center. (2004). CAC / RCP 57-2004 Code of Good Hygiene Practice for Milk and Milk Products, from [http://www.svssr.sk/dokumenty/legislativa/CAC\\_RCP\\_57-2004.pdf](http://www.svssr.sk/dokumenty/legislativa/CAC_RCP_57-2004.pdf).
- [9] TESTO. (2017). Monitoring and cooling system, from [www.testo.org](http://www.testo.org).
- [10] State Veterinary and Food Administration of the Slovak Republic. (2017). Official Control Portal, from <http://www.svps.sk/puk/>.
- [11] Mercier, S, Villeneuve, S, Mondor, M. & Uysal, I. Time–Temperature Management along the Food Cold Chain: A Review of Recent Developments. *Comprehensive Reviews in Food Science and Food Safety*, 16(4), 647-667. DOI: 10.1111/1541-4337.12269.
- [12] Tanner D. (2016). Food Quality, Storage, and Transport. Reference Modul in Food Science, 2016, 1-5, Elsevier. DOI: 10.1016/B978-0-08-100596-5.03336-9.
- [13] Varjan, P., Rovňaníková, D. & Gnap, J. (2017). Examining Changes in GDP on the Demand for Road Freight Transport. *Procedia Engineering*, 192, 911-916, In 12th International Scientific Conference of Young Scientists on Sustainable, Modern and Safe Transport, TRANSCOM 2017. DOI: 10.1016/j.proeng.2017.06.157.
- [14] Kampf, R., Lizbetin, J. & Lizbetinova, L. (2012). Requirements of a transport system user. *Communications*, 14(4), 106-108. ISSN 1335-4205.
- [15] Paquette, J.C., Mercier, S., Marcos, B. & Morasse, S. (2017). Modeling the thermal performance of a multilayer box for the transportation of perishable food. *Food and Bioproducts Processing*, 105, 77-85. DOI: 10.1016/j.fbp.2017.06.002.
- [16] Nemec, F., Lorincová, S., Hitka, M. & Turínska, L. (2015). The Storage Area Market in the Particular Territory. *Nase More*, 62(Special Issue), 131-138. DOI: 10.17818/NM/2015/SI8.
- [17] Bartuska, L., Stopka, O., Chovancova, M. & Lizbetin, J. Proposal of Optimizing the Transportation Flows of Consignments in the Distribution Center. *Transport Means – 20th International Scientific Conference on Transport Means*, 05-07 October 2016 (pp. 107-111). Juodkrante, Lithuania. ISSN 1822-296X.
- [18] Yu, Y. (2016). Study on transport packages used for food freshness preservation based on thermal analysis. *Archives of Thermodynamics*, 37(4), 121-135. DOI: 10.1515/aoter-2016-0031.