TEMPERATURE AND HUMIDITY – TWO MAJOR CLIMATIC RISK FACTORS AFFECTING THE QUALITY OF CARGOES CARRIED BY SEA

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ABSTRACT

Every day, millions of tons of temperature sensitive goods are produced, transported, stored or distributed worldwide. For all these products the control of temperature and consequently the control of humidity is essential, mostly when it is about transportation of the goods by sea. The quality of these products might be changed rapidly when inadequate temperature and relative humidity conditions are not preserved during transport and storage. Temperature variations can occur in warehousing, handling and transportation. Recent studies show temperature-controlled shipments rise above the specified temperature in 30% of trips from the supplier to the distribution centre, and in 15% of trips from the distribution centre to the store. Lower-than required temperatures occur in 19% of trips from supplier to distribution centre and in 36% of trips from the distribution centre to the store (White, 2007). It is the scope of this paper to highlight the impact of air temperature and atmosphere humidity on the quality of goods carried by sea onboard maritime ships.

Keywords: *Temperature, humidity, air circulation velocity, cargo, maritime transport.*

1. INTRODUCTION

Throughout the process of transportation, a special attention should be paid to the preservation of merchandise properties and prevention of quality risks, in order to eliminate or diminish degradation and depreciation which may occur as a result of the effects of certain risk factors.

By merchandise properties we understand a cluster of typical features consistent with the specific functions of a product, its utilization value, as well as its quality.

Among the major risk factors, acting mainly in the maritime transport we specify herein the temperature, the humidity and the effects of air circulation velocity on the quality of goods shipped by sea.

2. TEMPERATURE AND HUMIDITY – CLIMATIC RISK FACTORS AT SEA

2.1. Impact of air temperature on the quality of goods shipped by sea

For each type of product intended to maritime transport it is required to ensure an optimal temperature status, because keeping it on a certain level during preservation influences both the maintenance quality and the lifespan of those products.

The preservation temperature must not fluctuate too much, especially in case of food products. This goal may be reached by proper ventilation of the storage area, procedure which can be performed either by natural way (opening of silo hatchways and ventilation cowls) or by special ventilation installations.

Temperature dropping under the levels set forth by standards may lead to alterations, such as freeze and dilation of products, precipitation, alteration of solubility and viscosity of oils and fats.

Increase in temperature above the standard levels entails a range of physical alterations, such as dilation and high pressure inside the tanks up to explosion. Also, metabolic processes are accelerated and losses of quantity occur in the products weight.

Any merchandise sensitive to temperature fluctuations demands the observation of certain requirements in this respect. If the temperature of storage areas on maritime vessels throughout the transport complies with the requirements, the necessary premises to maintain the quality of shipped merchandise are thus ensured.

2.2. Transport temperature fluctuation interval

The transport temperature is the optimal storage temperature of a product, which provides the best conditions to maintain its quality. For most goods (which do not fit the category of those under mandatory temperature control status), the optimal transport value ranges between +5°C and +20°C.

Of course, when different climate zones are crossed, different values are to be expected that is temperatures higher than +20°C for subtropical areas and lower than +5°C (even negative) for temperate areas, in winter time.

In such situations, preventive steps are called for, so that the temperature of storage area shall not exceed a high admitted level or does not decrease below a low admitted level.

If the high admitted temperature level is exceeded, considerable quality depreciations and even total spoilage of goods may occur due to the intensification of the enzymatic and microbiological processes.

High temperatures may lead to the occurrence of the phenomenon of overheating and even self-ignition of the shipped cargo (such as products with high content of oils).

Another significant example of spoilage is that of tobacco leafs which, exposed to temperatures above the high admitted threshold enter the stage of over ripening, crushing and transforming into powder.

High temperatures can be generated not only by climate fluctuations of crossed areas, but also by local sources inside the storage area, such as vicinity of tanks to heated fuel, vicinity of engine compartment walls, etc, with negative effects on the merchandise quality.

If the high temperature threshold is exceeded, depreciation may occur due to the formation of white frost on the products surface and in case of very low temperatures massive degradation can be recorded, like in case of volume expansion of products, due to frost.

From the previously presented examples, we can infer that many goods cannot withstand the maritime transport without temperature control within the storage area. Thus, some goods require heating (such as some oils), while others require a forced cooling process up to freezing (such as perishable products). The transport of such products is considered transport by controlled temperature and is carried out by using complex heating or cooling installations, as the case may be.

2.3. Impact of air humidity on the quality of goods shipped by sea

Although they carry very little weight in the total air components, water vapours present in the atmosphere have a considerable impact, as it is most visible from the daily weather fluctuations.

The fact that the atmosphere can have only a certain concentration of vapours, called saturation value and that it depends on the temperature is well known: the warmer the air, the larger the quantity of water vapours.

After the saturation value is reached, the evaporation process cannot continue, which means that the relative air humidity is 100%. For example, a60% humidity means that the air contains 60% water vapours by its saturation value.

a) The use of Molliere diagram in order to set the ratio between temperature fluctuation and relative air humidity

As aforementioned, also the relations between the two atmospheric parameters, relative humidity and temperature may be represented by way of Molliere diagrams (figure 1).

The lower the relative humidity, the more intense the water vapours sorption process is manifested, which leads to the pursuit of drying.

A reference parameter indicating the risk of condensation water occurrence is the dew spot temperature. In case of cooling, this temperature is the point when the content of water vapours in the atmosphere reaches its saturation value and if the cooling continues, the condensation water phenomenon occurs.

If the dew spot temperature is known, it is possible to estimate the risk of condensation water phenomenon occurrence for which the Molliere diagram shall be used where the air temperature and dew spot temperatures can be read on the Y coordinate, while the mix ratio – vapours (expressed in grams)/dry air (expressed in kilograms) can be read on the X coordinate.

The Molliere diagram presents the curves of relative air humidity, drawn at intervals of 10%. The first curve on the diagram basis is applicable to the value of 100%, therefore it represents the saturation curve.

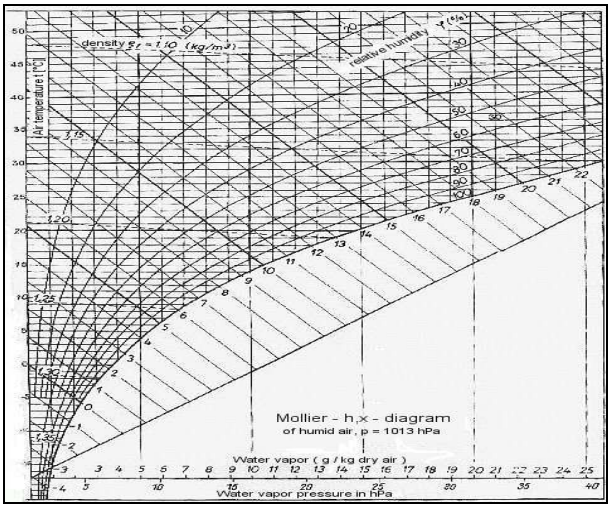

Figure 1 Molliere diagram of the possible ratio between temperature fluctuation and relative air humidity [17]

b) Sorption behavior of goods

Hygroscopicity is the term which describes the goods response capacity to the water content of air and the phenomenon manifests itself either by absorption, or water vapors elimination.

The crucial elements in the analysis of goods hygroscopicity are:

- Relative air humidity;
- Air temperature;
- Goods water content.

2.4. Classification of goods as per water content

The water content of a product is the water quantity of the total weight of that product, expressed in percents. Many hygroscopic products intended to maritime transport are organic.

However, there are inorganic products (many chemical products) which are also hygroscopic; therefore, a special attention should be paid to such characteristic during all transport phases.

Hygroscopic goods can mostly cause degradation of neutral products from hygroscopic point of view, such as metals or chemical products and therefore, a risk factor with regards to the occurrence of corrosion phenomenon.

Hygroscopic goods have the specific feature of variable water content, therefore being able to absorb humidity from the environment or releasing water vapours into it. Thus, in a relatively low humidity environment, such goods release water vapours, while in a relatively high humidity environment they absorb the humidity from the air.

This way, in case of hygroscopic goods, the water content changes and alterations in their total weight occur. Such a situation can generate more severe effects. Beside the aspect of quality alteration, depreciations what so ever may occur, leading to total depreciation of such goods.

A product is deemed dry when its water content does not affect its quality throughout the transport under normal weather conditions. For example, in case of organic goods, a high water content may generate the

occurrence of mould, rotting, as well as other biochemical alterations (for example, in case of cocoa and coffee beans).

For some products (usually in bulk), these manifestations are accompanied by the phenomenon of overheating, which can lead up to self-ignition (for example, in case of oilseeds, fodders containing oil residua, etc).

2.5. Determining sorbtion isotherms in case of goods within storage areas on maritime vessels

The term "sorption" is used to describe the characteristic of hygroscopic goods to absorb or eliminate water vapors in the environment until a state of balance is reached, as per the relative temperature and humidity of the environment.

The sorptional behavior is determined by the partial pressure gradient, where, according to the law of diffusion, the water vapors move always from the higher partial pressure to the lowest until the balance of vapors pressure is reached.

A sorption isotherm, such as the graphic representation of the sorptional behavior of a product, describes the relationship between the water content of such product and the relative humidity of air in the environment at a certain temperature.

In case of closed storage area (such as the ship's holds) we can determine the sorption isotherm depending on the water content of goods and the relative humidity within the storage area for a certain temperature, until the balance between the water content of goods and that of the air is reached, also setting the balance spot of water content.

The graphic representation of the statuses of balance between partial pressure of vapors for a certain product (depending on water content) and partial pressure of water vapors in the air for a specific temperature determines the sorption isotherm that describes the sorptional behavior of the product.

Therefore, if the water content of a product is known, it is possible to use the sorption isotherm diagram in order to determine how the product behaves in the storage area or how the climate in that area changes.

Throughout the determination of the statuses of vapors pressure balance between the product and the air, differences shall be recorded between the readings during adsorption and desorption.

The readings for the desorption isotherm are always a little higher than those for the adsorption isotherm. The specified differences reach their maximum amplitude for moderate readings of relative humidity.

In practice, the adsorption isotherm is used for a temperature of 20ºC, complying with the hygroscopic state of goods when the manufacturing process is complete.

The sorption isotherm profile is a characteristic of the hygroscopicity of a product.

Thus, the substances with high hygroscopicity have a steep sorption isotherm curve, whereas the products with low hygroscopicity have an almost straight sorption isotherm curve.

2.6. Effects of air circulation velocity on the quality of goods shipped by sea

The prevention of condensation water might be ensured by good storage ventilation, providing the cargo with optimal storage conditions throughout the maritime transport.

Adequate ventilation shall provide a constant flow of air in the storage areas, so that the heat, gases and smell emanations from goods may be evacuated, thus providing the temperature the goods need for an adequate keeping.

Storage ventilation is carried out through cowls which shall be oriented towards the resultant between the ship's heading and wind direction.

Besides the natural ventilation system, modern vessels are also equipped with an artificial ventilation system. This system, consisting of an electric fan installed in the cowls, provides controlled ventilation to the sense of forced air intake or exhaust within the storage areas.

The method of manually adjustable cowls or wind sails is simple and classic for all vessels carrying general goods. In such cases, temporary wooden air shafts are used inside the storage areas for providing cowl-intake air distribution among stacks.

In case of cargo that emanates gas, it facilitates the forming of strong sweat and even the stowage manuals recommend the opening of hatch covers during transport, under strict supervision, depending on weather condition, for natural ventilation inside cargo.

Of course, in case of automatic ventilation installations inside storage areas such manoeuvres for ventilation are no longer necessary. A permanent air flow of 1- 4 m/sec is provided by centralized control.

Anyway, an important ventilation measure, such as opening the hatch covers shall be permanently supervised and constantly entered in the log book. This shall remain as material evidence for each survey report, should it be required in the future.

In case of bad weather, too high humidity, too high outside temperature or rain, or waves going over the deck, the storage ventilation is to be cut off.

3. CONCLUSIONS

Most of the cargo loss or damage resulting cargo claims can be prevented by a proper maintenance of vessels and proper care of cargo.

If a vessel causes loss or damage to her cargo and if carriers are held liable, carriers would have to compensate cargo interests for their damages.

Furthermore, extra time and costs will be incurred in discharging the damaged cargo. In the worst case, cargo receivers might refuse to take delivery of the damaged cargo that results in delay in the vessel's departure.

Moreover, carriers' reputation may be deteriorated, which might result in loss of business. Accordingly, carriers are required to take proper care of cargo throughout their loading, navigating, discharging and delivering operations.

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