West of England

Loss Prevention Bulletin

Cargo Ventilation and Precautions to Minimise Sweat

"Moisture damage" is the source of a significant number of cargo claims, often involving bagged or bulk agricultural products. Claimants typically allege that failure by the ship to ventilate correctly resulted in the development of condensation (commonly known as "sweat"), causing the cargo to deteriorate. However, it is important to recognise that some commodities may have inherent moisture levels which exceed acceptable limits at the time of loading, making them biologically unstable. Such details may not be known to the ship, and prudent ventilation measures may be insufficient to prevent the cargo from deteriorating on passage. Nevertheless, claimants may still maintain that the ship was at fault.

To defend cargo deterioration claims it is necessary for the vessel to produce records showing that customary ventilation routines were followed. Should the necessary evidence be missing or incomplete, it is often difficult for the Club to refute such assertions.

General

Dry cargo vessels are fitted with either natural or mechanical ventilation systems. In addition to minimising the onset and degree of sweat, ventilation may also serve to remove taint and disperse any gases which some cargoes may emit.

The process requires close monitoring throughout the voyage as the moisture content of the cargo coupled with variations in air temperature, cargo temperature and sea temperature can dramatically influence the amounts of water vapour retained by and released into the air inside a hold.

Penetration of ventilating air into a bulk stow on a ship is minimal, and so it is only ever possible at best to provide through-surface ventilation. However, ship stability requirements usually dictate that at least the majority of the holds of any bulk carrier carrying bulk cargoes such as grain are loaded fully into the hatch coamings. For a hold so loaded it is unlikely that any significant through-surface air flow will be obtained. Whilst bagged cargo stows inevitably have some gaps in them, penetration of ventilating air beneath the uppermost layers of bags in the stow is minimal. Bagged cargoes should always be stowed in such a way that ventilating air can pass freely over the surface of the stow.

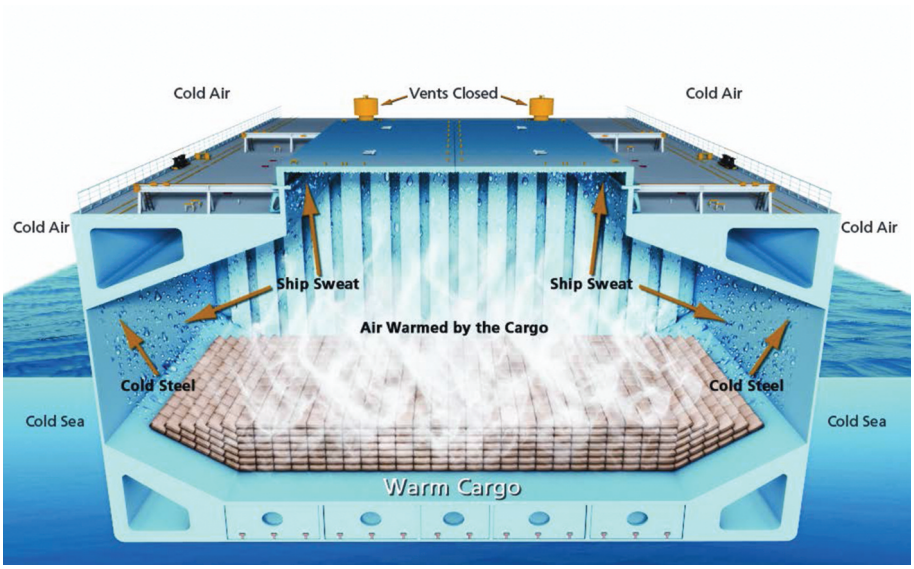
Cargoes at risk

Hygroscopic products

Hygroscopic products have a natural moisture content and are mainly of plant origin. They may retain, absorb or release water vapour, and excessive amounts of inherent moisture may lead to significant self-heating and "moisture migration" within the cargo resulting in caking, mildew or rot. Examples of hygroscopic products include grain, rice, flour, sugar, cotton, tobacco, cocoa, coffee and tea.

Non-hygroscopic products

Non-hygroscopic products have no water content. However, certain commodities (e.g. steel) may be damaged if stowed in a moist environment, and others may be harmed if packaged using a hygroscopic material (e.g. wood, paper). By way of illustration a vessel loaded a parcel of glass packed with layers of paper between each sheet. At the discharge port it was found that the paper had absorbed moisture from the air during the voyage, making it impossible for the glass sheets to be separated. The cargo was rejected by the receiver.

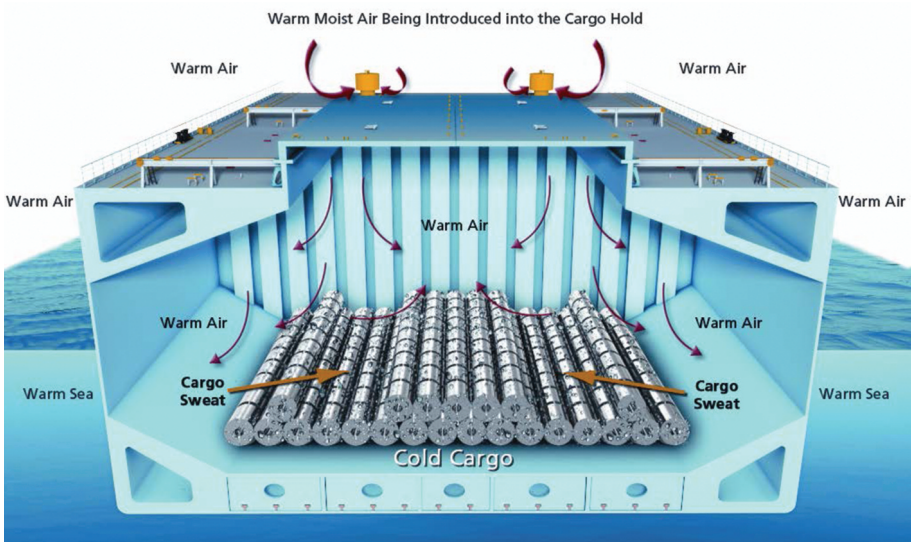


The Formation of Ship Sweat

Types of Sweat

Cargo sweat

Cargo sweat refers to condensation which may form on exposed surfaces of the stow as a consequence of large amounts of warm, moist air being persistently introduced into a hold containing substantially colder cargo.



The Formation of Cargo Sweat

Ship sweat

Ship sweat refers to condensation which forms directly on a vessel's structure when the air within a hold, made warm and moist by the cargo, comes into contact with cold surfaces as the vessel moves into cooler climates. Cargo may be damaged by overhead drips, by contact with sweat which has formed on the ship's sides or by condensed water which may accumulate at the bottom of the hold.

Influencing factors

Saturation

The amount of water vapour that air may contain is highly dependent on its temperature. A given volume of air is said to be saturated when no more water can be absorbed. If the air temperature then falls, condensation will occur. As air rises in temperature so does its saturation moisture content; its capacity to retain water climbs by ever-increasing amounts. Thus when air is cooled, its potential for releasing water in the form of condensation is far greater when it is cooling from higher temperatures than when cooling from lower temperatures. Apart from periods of fog or rain, ambient air is rarely saturated. Moreover, it will never be totally dry. Within these two extremes the amount of water retained by the air will vary according to the prevailing conditions.

Relative humidity

Relative humidity is the actual amount of water vapour in the air compared with the saturation amount of water vapour in the air at the same temperature and pressure. The figure is usually expressed as a percentage, with saturated air having a relative humidity of 100%. At main deck level, ambient sea air over the open oceans will normally have a relative humidity in excess of 80%.

Dewpoint temperature

When an isolated volume of air cools, relative humidity increases as the temperature falls. Once the temperature has descended to the level at which saturation occurs, water begins to condense. This temperature is known as the "dewpoint".

Dewpoint temperature may be measured by a variety of methods. Ships generally use a traditional wet and dry bulb arrangement consisting of two identical mercury thermometers, one of which has a damp muslin wick covering the bulb. These are normally housed in a protective marine screen on each bridge wing. The dewpoint temperature may then be determined by a "Dewpoint Table" to compare the wet and dry bulb temperatures. This figure is important when considering cargo ventilation requirements.

Wet and dry bulb thermometers

When using traditional wet and dry bulb thermometers, the accuracy of the dew point temperature will depend on the condition of the equipment. The muslin covering the wet bulb should be clean, the water in the reservoir should be distilled and the bulb itself should be wet.

In order to ensure that the readings are correct, the device should always be positioned away from any exhaust vents, other draughts and all sources of heat. The readings should always be taken on the windward side of the vessel.

Dewpoint measurement

Theoretically, all decisions regarding cargo ventilation should be based on dewpoint temperatures, comparing the dewpoint of the ambient air with the dewpoint of the air inside the hold. Given that most ships are customarily equipped with wet and dry bulb thermometers located close to the bridge, determining the dewpoint temperature of the ambient air is usually straightforward. However, ascertaining the dewpoint temperature inside a cargo space is more problematic. One of the simplest methods is to use a "whirling psychrometer", a handheld device containing wet and dry bulb thermometers and a water reservoir, swinging the instrument inside the hold until the wet bulb temperature has stopped falling and remains steady. The dewpoint temperature is again calculated using the Dewpoint Table.

All readings should be taken well away from any air inlets, ensuring that only hold air is tested. Enclosed space entry procedures should always be observed.

If access to the holds is impossible or undesirable, and

provided there is no significant air flow, wet and dry bulb thermometers may be placed in the trunking of an exhaust ventilator or similar pipework leading from the compartment, allowing the device to be drawn out and read from above deck.

Ventilation

Once the above information has been obtained, the rules are simple;

Dewpoint Rule

VENTILATE if the dewpoint of the air inside the hold is higher than the dewpoint of the air outside the hold.

DO NOT VENTILATE if the dewpoint of the air inside the hold is lower than the dewpoint of the air outside the hold.

Three Degree Rule

In many instances it is impracticable to measure hold dewpoint temperatures accurately, or at all. In such cases ventilation requirements may be estimated by comparing the average cargo temperature at the time of loading with the outside air temperature several times a day. Ventilation may then be carried out on the following basis; VENTILATE if the dry bulb temperature of the outside air is at least 3°C cooler than the average cargo temperature at the time of loading. DO NOT VENTILATE if the dry bulb temperature of the outside air is less than 3°C cooler than the average cargo temperature at the time of loading, or warmer. In order to apply the Three Degree Rule, it will be necessary for the ship's staff to take a number of cargo temperature readings during loading. Hand-held infrared thermometers are ideal for this task and are relatively inexpensive.

Further observations

During periods of heavy weather, steps should be taken to prevent rain and spray from entering the cargo spaces. This may mean suspending ventilation until conditions improve. If so, the circumstances should be logged. It is important to appreciate that ventilation should also be carried out during the night if the readings indicate that ventilation is appropriate. Ambient temperatures are usually lower therefore the risk of ship sweat developing is more likely during the hours of darkness. In addition to ventilating the holds according to the above regimes, it is important that regular inspections of each compartment are carried out where possible. This need not involve entry into the cargo space itself - for example, ship sweat may be seen forming on the underside of hold access covers. In such instances, and especially at night, the cargo should be ventilated irrespective of the Dewpoint Rule or the Three Degree Rule, weather permitting.

What to expect

In broad terms it is often possible to estimate ventilation requirements in advance by considering the climatic changes likely to be encountered during the voyage. The following examples indicate what may be expected on passage, but do not obviate the need for detailed monitoring and recording;

(Photo: 3D Marine USA Inc.)

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Steel Pipes Corroded as a result of Cargo Sweat

Hygroscopic cargo - cold to warm climate

If a stable cold cargo is carried to a warm climate, ventilation will always be unnecessary. Indeed, in some circumstances ventilation may lead to cargo damage.

Hygroscopic cargo - warm to cold climate

Vigorous surface ventilation of the cargo spaces will almost certainly be required due to the likelihood of ship sweat developing.

Non-hygroscopic cargo - cold to warm climate

Ventilation is never required. Cargo sweat is liable to occur if warm moist air comes into contact with cold cargo. Therefore holds should usually remain sealed to allow the cargo and internal air to warm gradually during the voyage.

Non-hygroscopic cargo - warm to cold climate

Ventilation is largely irrelevant. The development of significant ship sweat is very unlikely.

Combined cargoes

Problems may arise if hygroscopic and non-hygroscopic cargoes with different inherent temperatures are loaded into the same compartment. Their ventilation requirements may differ, resulting in damage to one or other of the products in spite of normal routines being followed. As far as possible, hygroscopic and non-hygroscopic cargoes should not be stowed together.

Stowage

Given the sensitive nature of many hygroscopic products and the possibility of sweat, efforts should be made to ensure that such cargoes do not come into contact with hold steelwork. This is particularly important in the case of bagged agricultural produce intended for human consumption such as rice, sugar, beans and flour. For bagged cargo, rows of dunnage or bamboo poles should be laid in the direction of the bilges to aid drainage, not more than 20 centimetres apart. A second layer should be placed on top at right angles to the first before covering the whole area with matting. If the cargo space is not fully fitted with cargo battens, bamboo poles or dunnage should be positioned crosswise against the frames to keep the bags away from the sides of the ship. Ideally, they should also be lashed together at the intersections to prevent them from becoming disturbed during loading. As an extra but not essential precaution, mats may be placed against this arrangement and the top surface of the stow may be covered with thick paper. Expert opinion today is that biologically stable bagged hygroscopic cargoes do not require ventilation channels, unless specifically demanded by the IMDG Code (e.g. some types of seed cake and fishmeal). Nevertheless, for certain commodities many charterers still require ventilation channels to be built into the stow. If so, the charterers should be asked for written instructions regarding the number and position of such channels, and these should be followed accordingly.

For hygroscopic cargoes a checklist detailing the steps and measures to be taken prior to and during loading, and whilst on passage, may be used.

Bunker tanks

Hygroscopic products may be damaged by localised sources of heat. Incidents have occurred where parts of parcels of grain have been scorched or have become discoloured when lying against hot bunker tanks. As far as possible, the bunkers used during the voyage should be drawn from tanks situated well away from holds containing hygroscopic products. If impracticable, bunker tanks adjoining cargo spaces should be heated only when required, ensuring that the temperature does not rise above normal operational levels.

(Photo: ATIC / Africa P&I Services)

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Bagged Rice Damaged as a result of Ship Sweat when in contact with Shell Plating in a Cargo Hold

Records

Ventilation records are crucial. In the event of moisture damage, evidence showing that the vessel ventilated correctly may be instrumental in defending any ensuing claims. If the Dewpoint Rule has been followed, wet and dry bulb temperatures and dewpoints should be logged once per watch, bearing in mind that these may change considerably over a short period. For the same reason, the sea temperature should also be noted. This information should be recorded for each hold together with the times of commencing, ceasing or resuming ventilation, and the reasons for doing so.

If the Three Degree Rule has been followed, a record should be kept of the ambient air temperature and the sea temperature once per watch together with the average temperature of the cargo at the time of loading. Again, ventilation details should be documented for each hold.

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