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The Japan Ship Owners Mutual Protection & Indemnity Association Loss Prevention and Ship Inspection Department

VENTILATION

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Introduction

This article explains the basics of cargo ventilation. It focuses on the ventilation of cargo spaces on conventional ships and does not relate to the ventilation of containers or refrigerated compartments. For the purpose of this article, ventilation is defined as the intentional introduction of air from the external environment into and through a cargo space, and the exhausting of the in-hold air. Ventilation as so defined may be required for several reasons, but these mainly relate to either the safety of people or the appropriate care of the cargo. The latter is the main focus of this article, which covers the aims of appropriate ventilation, the cargoes most at risk of sweat damage, and the practicalities of applying conventional cargo ventilation.

Safety

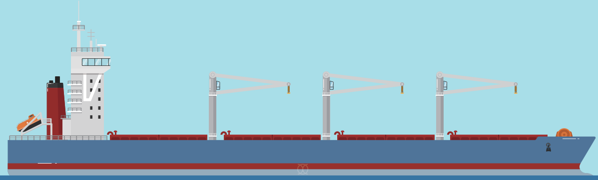
Ventilation may be needed to ensure that there is a sufficient oxygen supply for safe personnel entry into the cargo space. Similarly, ventilation may be needed to remove poisonous and flammable gases which could give rise to a dangerous situation. These gases might be produced by the cargo itself, e.g. evolution of carbon monoxide from a heating coal cargo. Alternatively, they may originate from another external source, e.g. phosphine gas evolution during cargo fumigation (see Japan P&I Loss Prevention Bulletin Vol.22, March 2012, for the dangers associated with fumigant gases). Regardless, ventilation in this sense, sometimes referred to as 'aeration', requires the measurement of the gases present in the air until such a time that they can be considered to have returned to normal or 'safe' levels. It is not primarily concerned with the care of the cargo.

Cargo care

Apart from the above safety reasons, the main aim of ventilating cargo spaces is to minimise condensation, or so-called 'sweat', forming inside the cargo space. This can be an important aspect of caring for a particular cargo while it is in the custody of the master of the carrying vessel. A failure to do so may result in cargo damage and thus a cargo claim at outturn. When deciding whether or not to ventilate a cargo compartment to eliminate/minimise sweat formation, the crew must measure and compare the external air temperature with that of the cargo itself, or the air inside the cargo space (more on this later in the article).

What is sweat?

In shipping, 'sweat' is the term used to refer to the formation of condensation in the cargo compartment. See Box 1 for more detail on the relationship between air temperature, dew point, and sweat formation. In the context of cargo damage arising from condensation, we tend to talk about 'cargo sweat' and 'ship's sweat'. The assignation of these terms simply reflects the visual appearance of the phenomena, but both are misnomers since neither the cargo, nor the ship, can perspire in the true meaning of the word. These are explained in more detail here.



Cargo sweat

When condensation forms directly on the cargo it is referred to as 'cargo sweat' (see Photo 1). Cargo sweat is a potential problem when relatively cool cargoes are carried through relatively warm climates and (inappropriately) ventilated with the warmer air. When the warm air enters the cargo space and comes into contact with the cool cargo, water vapour will condense out into liquid water onto the exposed surfaces of the cargo, if the air is cooled to below its dew point. In this way, it appears that the cargo is 'sweating'.

Formation of condensation on the surface of rolled steel cargo, known as cargo sweat. It is most commonly a problem when cool cargoes are inappropriately ventilated with warm air.

Photo 1.

Ship's sweat

When condensation forms on the steelwork in the ship's hold it is referred to as 'ship's sweat'. This commonly occurs on the coaming and underside of the hatch covers (see Photo 2) where it may then drip back down onto the cargo surface beneath, producing a characteristic pattern of damage (see Photo 3). Ship's sweat typically arises when a warm or self-heating cargo is carried through cooler climates and the headspace is not sufficiently ventilated to replace the warm moist air within it with cooler external air. As this warm moist air in the headspace comes into contact with the cool steel structures of the ship (which are cooled by the lower external air and/or sea temperatures), the air is cooled below its dew point and water vapour condenses into liquid water. The liquid moisture often runs down and off the surfaces, giving the appearance that the ship is 'sweating'.

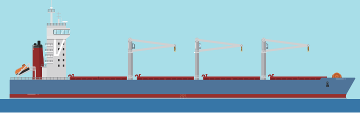
Photo 2.

Formation of condensation on the underside of the hatch covers, otherwise known as ship's sweat, where warm moist air meets cool steel and the moisture vapour condenses into liquid water.

Photo 3.

Characteristic damage to a grain cargo arising from ship's sweat. A distinctive linear pattern of superficial deterioration (discolouration and mould growth) at the surface of the stow, where liquid moisture has dripped back down onto this bulk grain cargo from the underside of the closed hatch covers. The banding pattern mirrors the layout of the metal structures above.

■ VENTILATION



Box 1 The science behind ‘sweat’

At any given temperature, air can hold a maximum amount of moisture as water vapour. This is referred to as the saturation moisture content. It can be measured (either the mass of moisture in the air or the pressure exerted by that moisture) and standard tables have been published listing the saturation moisture content at a particular temperature.

When the air is not fully saturated at any given temperature, then the actual quantity of moisture in that air is expressed as a percentage of the saturation moisture content at that temperature. This is known as the relative humidity.

When air at a given temperature and relative humidity is cooled to the temperature at which it reaches its saturation moisture content, that lower temperature is known as the dew point. Further cooling below the dew point temperature causes the moisture in the air to condense out as liquid moisture, i.e. condensation or ‘sweat’ forms.

EXAMPLE:

According to standard tables the mass of moisture in saturated air at 20°C is 17.30g/m^3.

If that air was actually found to contain only 10g/m^3 of moisture, then its relative humidity would be 58% (10 ÷ 17.30 x 100) at 20°C .

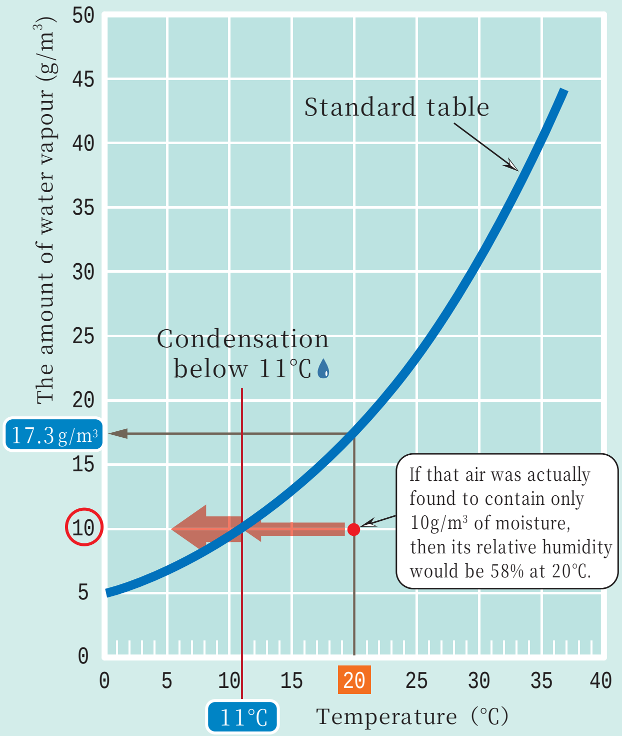
At 11.1°C the mass of moisture vapour in saturated air is 10.08g/m^3.

On that basis, air at 20°C and 58% relative humidity, would have a dew point of 11°C .

If that same air were to be cooled below 11°C then condensation or ‘ sweat ’ would form.

Because of this relationship, the dew point can also be used as a measure of the amount of moisture in the air.

Temperature (°C)	30	25	20	15	10	5
Saturation moisture content (g/m^3)	30.4	23.1	17.3	12.8	9.4	6.8



Which cargoes are most at risk?

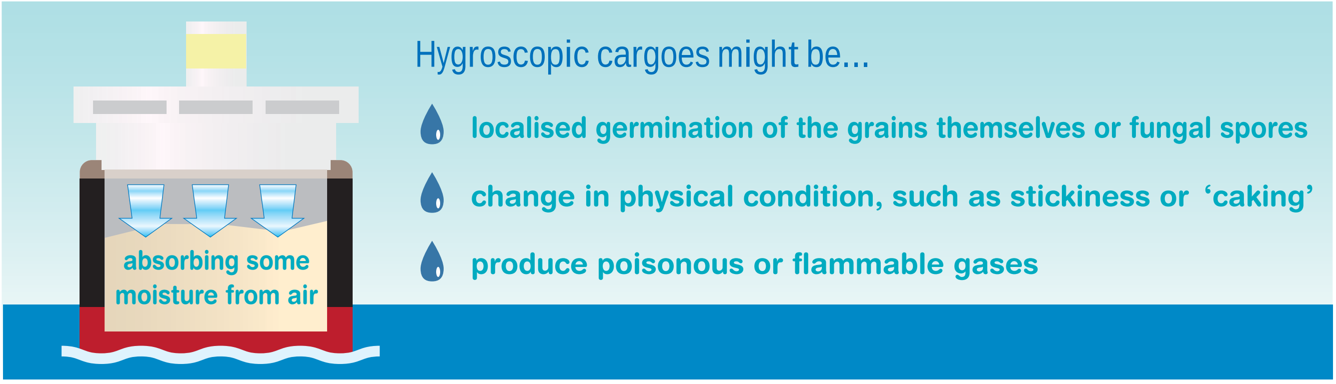
Cargoes that are susceptible to damage caused by sweat are those that will deteriorate in some way when in contact with water. These cargoes may be either hygroscopic or non-hygroscopic. Hygroscopic cargoes are those which have an inherent moisture content that can interact with the air (see Box 2). Non-hygroscopic cargoes are those that do not have an inherent moisture content, or at least not one which can interact with the air.

Typically, hygroscopic cargoes are natural products, such as grains, oilseeds, cocoa beans, timber, etc., or products derived from them, such as meals, seedcakes, and other animal feeds, etc. Such cargoes require appropriate ventilation to eliminate or at least minimise damage arising from contact with liquid water. It must be remembered that their safe carriage is dependent on the moisture content at which they are loaded. As a result, introduction of additional moisture (condensation) may result in localised germination of the grains themselves or fungal spores that are always present. Typically, the pattern of this deterioration closely mirrors the source of the moisture (see Photo 3).

Photo 3

Rice packaged in woven polypropylene bags behaves as a hygroscopic cargo in relation to the air in the headspace. Cargo claims for condensation damage to bagged rice cargoes are common, especially for the trade from South-east Asia to West Africa. In many such cases, a characteristic pattern of damage is seen whereby the bags all around the periphery of the stow tend to be more affected than those further into the stowage. These claims often lead to allegations of inappropriate stowage, dunnaging, and/or ventilation (see Box 3).

Cargoes such as sugar and fertiliser are theoretically hygroscopic, but are not usually ventilated. This is because the moisture content of these cargoes is so much lower than the ventilating air, such that the cargo would almost always absorb some moisture from the air being introduced. This may lead to a change in physical condition, such as stickiness or ‘caking’, and ultimately a claim may be lodged on outturn from the vessel. Additionally, these cargoes are often packaged in woven polypropylene bags with a polypropylene liner. In that case they no longer behave as a conventional hygroscopic cargo with regards to the air in the cargo space and instead the cargo interacts only with the air inside the bag. In such circumstances, ventilation would be of little or no benefit to the cargo, but could still cause cargo sweat damage if applied inappropriately.



Other hygroscopic cargoes (e.g. coal, fishmeal, coke, direct reduced iron, etc.) can react with oxygen in the air to produce heat and sometimes poisonous or flammable gases. In such cases, guidance from an expert is often required to advise on a gas monitoring and ventilation regime needed to minimise the risk of a dangerous or explosive situation developing on board the ship, but at the same time minimise the risk of introducing further air (and thus oxygen) into the cargo space that may potentially exacerbate the situation.

Several non-hygroscopic cargoes may also be at risk of sweat damage because they interact with liquid moisture. One common example is steel products, such as coils, sheets, pipes, etc., that may react with the moisture to form rust. See Japan P&I Loss Prevention Bulletins Vol.19 (August 2010) and Vol. 20 (April 2011) which focus entirely on the risks associated with the carriage of steel products. In addition to the risk of cargo sweat damage, such cargoes are often dunnaged with large amounts of hygroscopic material (e.g. timber) which may lead to the formation of ship's sweat if inappropriately ventilated (see the section Taking the Decision to Ventilate for more on this).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はじめに

毎年何万トンもの様々な形態の鋼材が世界中で輸送されています。鋼材の主要輸出国といえば日本や北欧諸国ですが、今日ではロシアやバルト諸国、そしてブラジルやインドの輸出も増加しています。一方、米国は相当量の鋼材を輸入しており、また世界中の国々の間で多くの輸出入取引が行われています。鋼材の輸送には主に撒積貨物船が使用されており、より小規模なものでは一般貨物船による輸送がありますが、稀にコンテナ輸送を主とする船舶によっても輸送が行われています。

鋼材には比較的価格の安い未完成品 / 半製品と、価格の高い完成品があります。しかし価格に関わらず、全ての鋼材は湿気による発錆や接触による物理的ダメージ、またコンタミネーションによる損傷を受けやすく、船荷証券に表示されていない損傷や欠陥が明らかとなった場合、荷受人から運送した船舶の責任を問われる可能性が高くなります。

本号および次号では鋼材輸送に関し様々な考察を行います。本号では鋼材の種類とその積付まで

Introduction

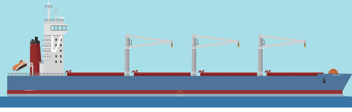
Many millions of tons of steel in its various forms are shipped around the world each year. The major exporters of steel products are Japan and Northern Europe, with exports increasing from Russian, Baltic States, Brazil and India. The USA imports a significant quantity of steel products and there is extensive cross-trading between other nations around the world. These days much of the steel is carried by bulk carriers, with smaller shipments being carried by general cargo vessels and, occasionally, by vessels designed primarily for the carriage of containers.

Some steel products are unfinished or semi-finished and are of relatively low value, whilst other products are finished and are of relatively high value. Regardless of value, all types of steel products are susceptible to damage by rusting following wetting, by mechanical damage following contact and by contamination. Receivers of steel products which display any form of damage or defect which is not described on the bill of lading are likely to pursue a claim against the carrying vessel.

In this article, the first of two which deal with the carriage of steel products, we will discuss the various types of steel

— 1 —

In the event of sweat damage and a cargo claim, the actions of the crew with regards to cargo stowage and ventilation may come under scrutiny. The rest of this article covers the more practical aspects of deciding when to ventilate, how that ventilation will be applied, and the documentation of that ventilation.



Box 2 Hygroscopic cargoes, the equilibrium relative humidity, and ventilation

The temperature and moisture content of the air in an unventilated cargo space containing a hygroscopic cargo is governed by the characteristics of the cargo itself.

Hygroscopic cargoes loaded at a given moisture content and at a particular temperature will initially either absorb moisture from, or give up moisture to, the air surrounding the cargo. This process continues until an equilibrium is reached whereby no further absorption or desorption occurs. The relative humidity of the air adjacent to the cargo at which the equilibrium is reached is referred to as the Equilibrium Relative Humidity (ERH).

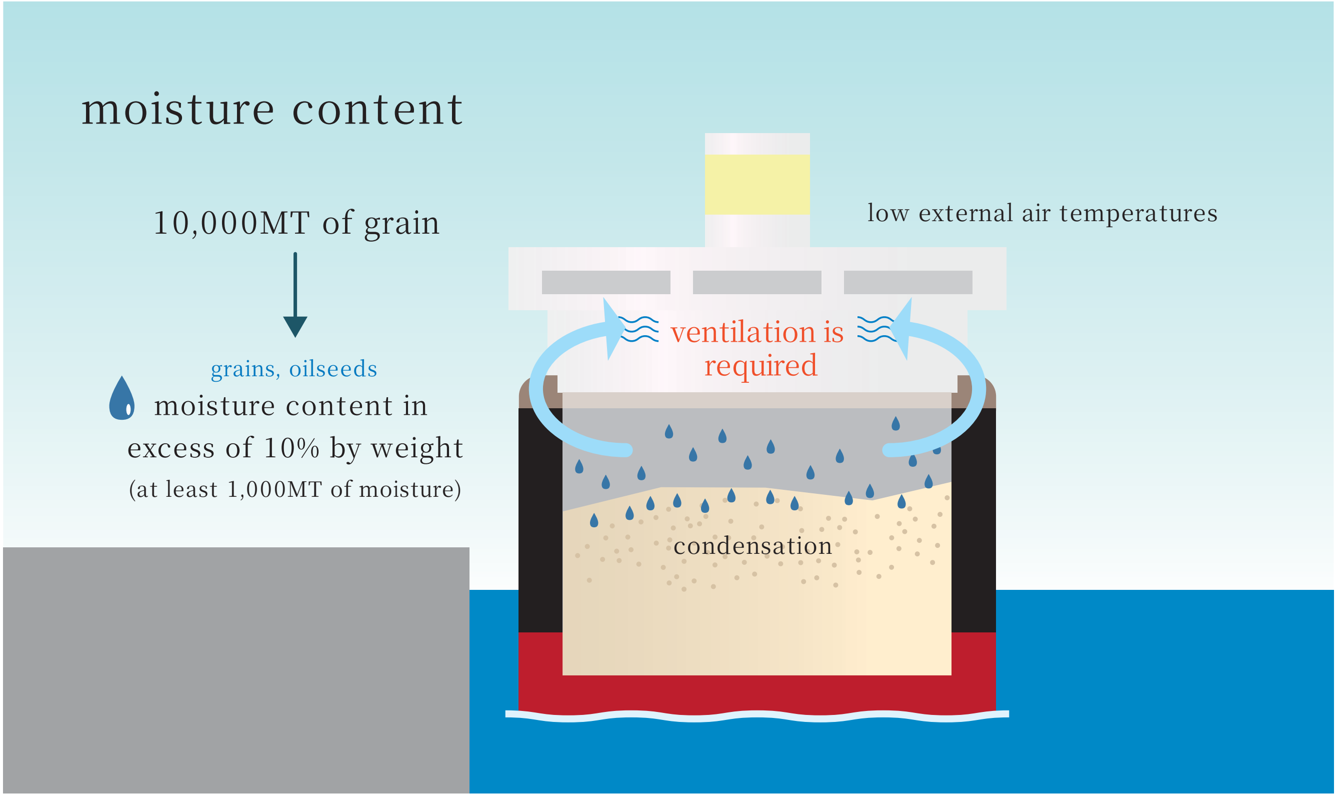
The ERH at the surface of many agricultural products (e.g. grains, oilseeds, etc.) determines whether or not fungal spores (mould) at the grain surface can germinate and grow. The majority of storage fungi associated with these cargoes can germinate at an ERH of around 65-70% or higher. The ERH will increase at higher moistures contents or higher temperatures. This is partly the reason why such cargoes should be protected from sources of additional moisture and heat during carriage.

Many grain cargoes are dried prior to entering into storage (whether ashore or on board a vessel for carriage) with the intention that the ERH at the surface of the grains is sufficiently low (i.e. below 65-70%) in order to minimise the risk of spoilage during carriage. Unfortunately, in reality, many cargoes shipped around the world are not sufficiently dried and spoilage from mould growth is a common result.

That being said, even when cargoes are sufficiently dried, the moisture content of many grains and oilseeds at the time of shipment is still substantial. Many are shipped at a moisture content in excess of 10% by weight. In such a scenario, a cargo space containing 10,000MT of grain contains a reservoir of at least 1,000MT of moisture within that grain. This represents a much greater quantity of moisture than can ever be contained within the air inside the hold.

This means that if conditions are such that condensation is occurring in the headspace above a hygroscopic cargo, the moisture lost from the air as condensation will be replaced by moisture from the hygroscopic cargo reservoir.

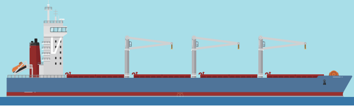
If conditions remained the same (i.e. low external air temperatures are maintained), then a continuous process of condensation could be established. Under such conditions, it would be necessary to ventilate to minimise damage arising to the cargo from that condensation (i.e. ship's sweat).



The introduction of cooler air into the headspace by ventilation would result in that air being warmed by the cargo below, since the temperature of the cargo mass governs the air temperature in the hold. As the ventilating air was warmed, its relative humidity would reduce and moisture would be taken up into the air (until the ERH was approached).

If conditions were such that it was appropriate to continue ventilation then that ventilating air (and the moisture it contained) would be continuously removed from the headspace, thereby minimising the risk of sweat damage. If the conditions changed such that condensation was not occurring in the headspace (i.e. external air temperatures rose, and therefore that of the ship's steelwork), then ventilation would no longer be required.

VENTILATION



Box 3 Bagged rice cargoes; stowage and dunnaging

Cargo claims for condensation damage to bagged rice cargoes are common and are often based on allegations of inappropriate stowage, dunnaging, and/or ventilation.

Appropriate dunnaging can minimise the risk of cargo damage from any sweat that may form. When dunnaging is properly constructed (using flat board timber, wooden struts and/or bamboo mats) variously on the tank top and around the sides of the stow, it can effectively maintain an air gap of a few centimetres between the cargo and the steel structures of the ship. This means that any sweat which may form on the steelwork at the sides and bottom of the cargo space will not come into contact with the cargo. In such a system, sweat can run freely down the steel and drain aftwards to the hold bilges.

In more recent times, it has become common in the bagged rice trade from South-east Asia for this traditional type of dunnaging to be replaced by the placement of Styrofoam blocks against the hull as a means of insulation, then a covering of plastic sheeting is fitted, often topped with a layer of Kraft paper, before bags are stowed against the Kraft paper. This is sometimes called the 'Allied' system, after the rice trading company that introduced it. They championed the system on the basis that it insulated the cargo from the external conditions such that sweat damage would be eliminated. While this may be true relative to the use of no dunnaging at all, in reality this has not been the case and bagged rice cargo claims arising from sweat damage have continued (with or without the use of the Allied system).

In addition, it has also become common in this trade for trenches or 'ventilation channels' to be built into the stowage as the bags are stowed in the holds. Emphasis has been placed on their importance, seemingly based on a theory that they can in some way facilitate better exchange of air in the cargo space. However, this is unlikely to be the case. Bagged rice cargoes are hygroscopic and the temperature and dew point of the air in the channels will be determined by the temperature and moisture content of the rice. Therefore, the channels themselves are of little or no benefit in preventing sweat damage. The risk of sweat forming may be just as likely for a block stowage as when ventilation channels are built into the stowage.

Of course, as with all cargoes, care should be taken during the loading of bagged cargoes to prevent bags being stowed in a way which would prevent the exchange of air across all parts of the headspace. Ventilation openings into the cargo space must not be obstructed.

Pause for thought

Before loading commences, the Master and Chief Officer need to give careful consideration to the stowage of the cargo and whether or not ventilation may need to be applied during the voyage. In some cases, charterers may have provided clear guidelines for cargo stowage and ventilation in their voyage/carriage instructions. These should be read carefully and any queries raised prior to the voyage. When ventilation instructions have not been provided, a prudent Master would be expected to consult standard industry reference material (e.g. textbooks, P&I loss prevention publications, etc.) for guidelines on stowage and whether or not the cargo may need to be ventilated during the voyage, in addition to using his own knowledge and experience.

Taking the decision to ventilate

In order to eliminate/minimise the formation of sweat and the associated risk of cargo damage, the fundamental decision taken by the Master to ventilate the cargo space or not should be based on either the 'Dew Point Rule' or the 'Three Degree Rule'. These are defined as follows:

'Dew Point Rule' or 'Three Degree Rule'

- The Dew Point Rule states that a cargo hold should be ventilated when the dew point of the outside air is lower than the dew point of the air inside the cargo space.
- The Three Degree Rule states that a cargo hold should be ventilated when the dry bulb temperature of the outside air is at least 3°C lower than the temperature of the cargo.

Both rules are a suitable means of deciding whether or not it is appropriate to ventilate. The Three Degree Rule is based on the Dew Point Rule and was derived scientifically for use with hygroscopic cargoes (assumed to be at 70% ERH and subject to ventilating air at 80% RH). Although by definition an ERH cannot be established for non-hygroscopic cargoes (see Box 2), the Three Degree Rule can still be extended as a general rule of thumb for non-hygroscopic cargoes. This is because both the Three Degree Rule and the Dew Point Rule essentially seek to minimise the risk of sweat forming in the cargo space, either on the ship's steelwork or on the cargo, by replacing relatively warm/moist air with relatively cool/dry external air. However, there are pros and cons for using both rules. These are briefly outlined here.

To determine the dew point of the air, it is necessary to obtain a dry bulb and a wet bulb temperature and then compare the values to determine the dew point from standard published tables (see Box 4). The dry bulb is a standard thermometer, whereas the bulb of the wet bulb thermometer is surrounded by a muslin wick that is submerged in pure water. To obtain an accurate reading a sufficient flow of air needs to be achieved over the wet bulb. The drier the air that passes over the wick, the greater the amount of moisture which will be lost from the muslin to the air, and therefore the greater the cooling effect will be on the wet bulb. The difference or 'depression' of the wet bulb reading against the dry bulb reading is used with standard tables to calculate the dew point.

One wet and dry bulb pairing is normally housed in a Stevenson screen near to the bridge and it is these which are used to measure the conditions of the external air. The location of the Stevenson screen allows for an effective air flow over the wet bulb and means that the external air dew point can be accurately determined. The problem often arises when trying to accurately determine the wet bulb temperature in the cargo spaces to be ventilated.

To obtain an accurate reading a sufficient flow of air needs to be achieved over the wet bulb. This can be achieved in an enclosed space by use of a whirling hygrometer. While theoretically possible in a general cargo ship, where the cargo spaces can be accessed by the crew, these days most cargoes that require ventilation are carried in bulk carriers where it is impractical (if not impossible or unsafe) to obtain such a measurement. Furthermore, in bulk carriers the cargo is often loaded up into the coaming space and it is difficult, if not impossible, to get accurate readings of the air in the headspace.

Seemingly in an attempt to combat this, it has become common practice to place portable wet and dry bulb thermometers on the end of rope inside the access manholes (see Photos 4 and 5). In cases where the cargo feeder holes in the coamings are not obstructed and the cargo is not fully loaded up into the manhole access trunkings, then the air being measured below the accesses will be continuous with the headspace. However, this is not always the case. Moreover, in an unventilated hold there will be little or no airflow and so the wet bulb temperature cannot be accurately determined. On the other hand, in a hold under ventilation, in all likelihood, the wet bulb would be measuring the ventilating air passing through the hold, and not the hold air.

Photo 4

Photo 5

Placing of portable wet and dry bulb thermometers in the access manholes has become commonplace on board bulk carriers, but it is extremely difficult to obtain an accurate wet bulb reading and the air may not necessarily be connected to the headspace in any case.

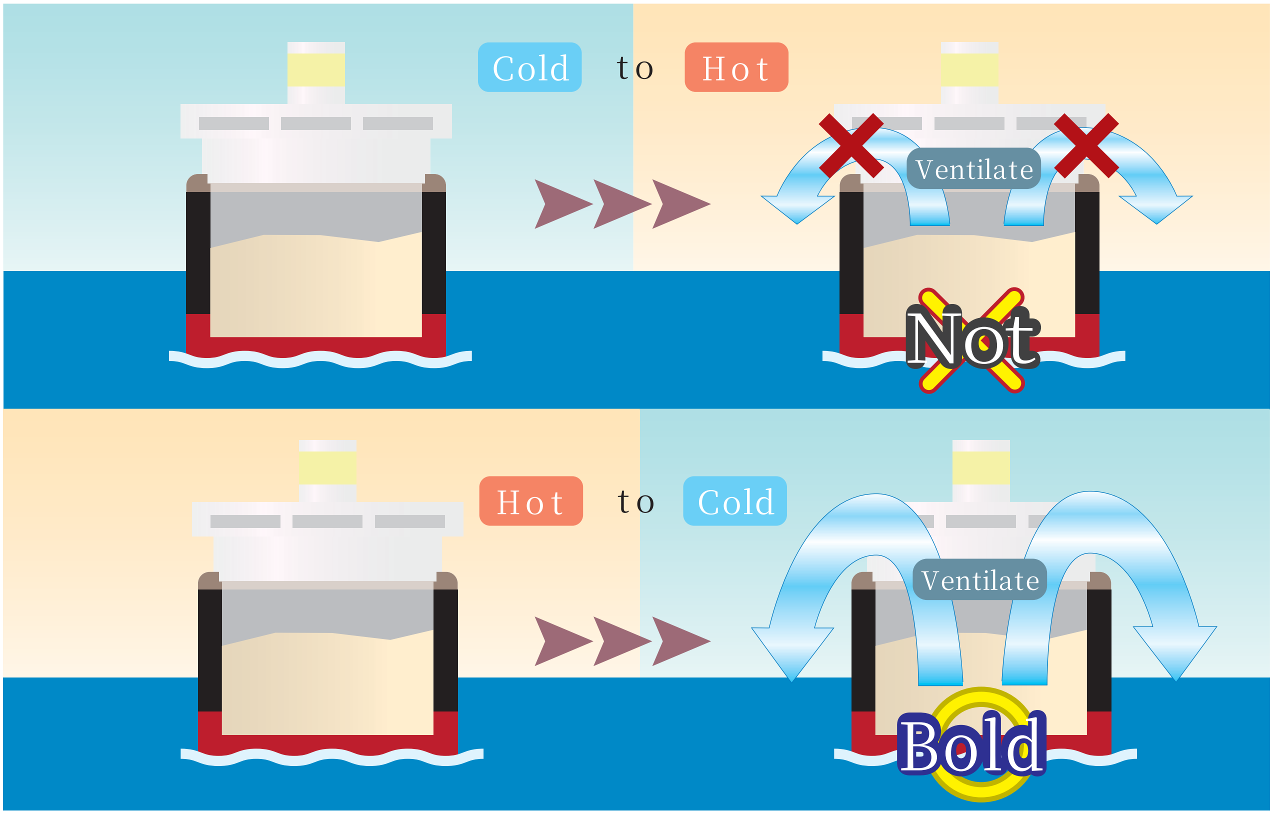
No such difficulties are faced when using the Three Degree Rule, which only requires reliable cargo temperatures obtained during loading and reliable external dry bulb temperatures during the voyage. However, this rule makes the assumption that the cargo temperature remains relatively constant during the voyage. This is a reasonable assumption for many cargoes, but experience shows that this is not always the case.

In cargoes, such as seed cake or soya beans, that can sometimes be loaded in a condition that leads to self-heating during the voyage, then basing the decision to ventilate on a loading temperature may give rise to cargo damage, since that loading temperature may be substantially below the actual temperature of a heating cargo during the voyage. Even if the crew suspect the cargo temperature may have altered since loading, accessing the cargo spaces during the voyage to take additional cargo temperatures may not be practical (e.g. risk of cargo wetting from sea spray) or safe (e.g. cargo spaces under fumigation).

Difficulties may arise for different reasons when a combination of cargo types is being carried in a single compartment or in different decks on board a 'tween decker general cargo vessel. For example, steel products and timber products, or other hygroscopic items, together in one compartment or in different decks. In that scenario, the hygroscopic cargo must be ventilated in such a way that cargo sweat does not form on the steel cargo. The temperature of the steel cargo should be obtained during loading, as if the Three Degree Rule is to be used, and the procedures of the Dew Point Rule may be used during the voyage to establish the dew point temperatures and a balance must then be sought so that sweat does not form on either the steelwork of the vessel or the steel items of cargo.
For the carriage of general cargo items or mixed cargoes there are two broad rules of thumb which can be borne in mind and used in conjunction with the Rules given above, they are:

- Cold to Hot — Ventilate Not
- Hot to Cold — Ventilate Bold

Two broad rules



During a voyage from a cold area to a warmer area the cargo will generally remain cold while the structures of the vessel will get warmer and the dew point of the outside air is likely to be above the temperature of the cargo – therefore do not ventilate. Whereas during a voyage from a warmer area to a colder area the steelwork of the vessel will become colder while the cargo will remain warm and ship's sweat is likely to occur, at the same time the dew point of the outside air is likely to be below that of the air inside the hold, therefore ventilate to avoid the formation of ship's sweat.

These examples are simplified and in practice all appropriate measurements must be taken and ventilation/no ventilation must be carried out bearing in mind all the circumstances, day to day.

VENTILATION

Box 4 Example of a standard dew point table

Applying ventilation

How ventilation is applied to a cargo space is dependent upon the ventilation system with which the ship is equipped. Conventional ventilation systems are normally either natural (passive) or mechanical (fan-assisted). In both cases, the object of the ventilation system is to allow replacement of air inside the cargo spaces.

To achieve this all ventilation systems must have both inlet and outlet ventilation openings at opposite ends of the cargo space. The ventilation openings may be at deck level (sometimes in purposely designed ‘mushrooms’), in the hatch covers (see Photo 6), or sometimes on the crane masts or associated housing. This basic layout is often true of both natural and mechanical systems, but in the case of the latter there is an additional fan component.

Starboard side forward and aft ventilation covers in the hatch panel in the open position for natural ventilation on board a bulk carrier. Since natural ventilation is limited when the vessel is stationary, here the hatches have been jacked-up to facilitate a better exchange of air while the vessel is alongside the berth.

Photo 6

Obviously, the crew need to be able to open or close these openings to apply or stop ventilation when conditions dictate. It is also important that the cargo is stowed in such a way that the openings are not obstructed inside the cargo space. This is extremely difficult to rectify after the event, reinforcing the need to give careful consideration prior to loading as to whether ventilation of the cargo will be needed during the voyage.

Dry Buld °C	0°	0.2°	0.4°	0.6°	0.8°	1.0°	1.2°	1.4°	1.6°	1.8°	2.0°	2.5°	3.0°	3.5°	4.0°	4.5°	5.0°	5.5°	6.0°	6.5°	7.0°	7.5°	8.0°	8.5°	9.0°	Dry Buld °C
40	40	40	40	39	39	39	39	38	38	38	38	37	36	36	35	34	34	33	32	32	31	30	29	29	28	40
39	39	39	39	38	38	38	38	37	37	37	37	36	35	35	34	33	33	32	31	31	30	29	28	28	27	39
38	38	38	38	37	37	37	37	36	36	36	35	35	34	34	33	32	32	31	30	29	29	28	27	26	26	38
37	37	37	37	36	36	36	36	35	35	35	34	34	33	32	32	31	30	30	29	28	28	27	26	25	24	37
36	36	36	36	35	35	35	34	34	34	34	33	33	32	31	31	30	29	29	28	27	26	26	25	24	23	36
35	35	35	34	34	34	34	33	33	33	33	32	32	31	30	30	29	28	28	27	26	25	24	24	23	22	35
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33	33	33	32	32	32	32	31	31	31	31	30	30	29	28	28	27	26	25	25	24	23	22	21	20	19	33
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21	21	21	20	20	20	19	19	19	19	18	18	17	16	15	14	13	12	11	10	9	8	6	5	3	1	21
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13	13	13	12	12	11	11	11	10	10	9	9	8	7	6	4	3	1	0	-2	-4	-7	-9	-13	-17	-23	13
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5	5	5	4	4	3	2	2	1	1	0	0	-2	-4	-6	-8	-10	-14	-15								5
4	4	4	3	2	2	1	1	0	0	-1	-1	-3	-5	-7	-10	-11	-14	-18								4
3	3	3	2	1	1	0	0	-1	-2	-2	-3	-5	-7	-8	-11	-14	-17									3
2	2	2	1	0	0	-1	-1	-2	-3	-3	-4	-5	-8	-10	-13	16										2
1	1	1	0	-1	-1	-2	-2	-3	-4	-4	-5	-7	-9	-12	-15	-19										1
0	0	-1	-1	-2	-2	-3	-4	-4	-5	-6	-7	-9	-11	-14	-18											0
-1	-1	-2	-2	-3	-4	-4	-5	-6	-6	-7	-8	-10	-13	-17												
-2	-2	-3	-4	-4	-5	-6	-6	-7	-8	-9	-10	-12	-15	-19												
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-15	-17	-18	-19																							
-16	-18	-19																								
-17	-19																									

lines

In the table, lines are ruled to draw attention to the fact that above the line evaporation is going on from a water surface, while below the line it is going on from an ice surface. Owing to this, interpolation must not be made between figures on different sides of the lines.
For dry bulb temperatures below 0 ˚C it will be noted that, when the depression of the wet bulb is zero, i.e. when the temperature of the wet bulb is equal to that of the dry bulb, the dew-point is still below the dry bulb, and the relative humidity is less than 100 per cent. These apparent anomalies are a consequence of the method of computing dew-points and relative humidities now adopted by the Met Office, in which the standard saturation pressure for temperature below 0 ˚C is taken as that over water, and not as that over ice.

DEWPOINT TABLE
Table (7.38.1)
(For use with marine screen)

Although mechanical ventilation fans can be engaged to achieve ventilation continuously, natural ventilation systems are largely dependent on the external wind conditions, i.e. the relative air flow across the vessel. When conditions are such that there is no air flow over the vessel, the use of natural ventilation openings alone may not achieve a satisfactory air exchange. Under such circumstances, and only when sea/weather conditions allow, and only when the vessel is alongside or at a sheltered anchorage, more effective ventilation can sometimes be achieved by slightly opening the hatch covers (see Photo 7). However, during such ventilation, care needs to be taken to prevent wetting of the cargo from external sources of moisture, such as rain. Indeed, it may not be appropriate to do this while the vessel is underway at sea.

Since natural ventilation is limited when the vessel is stationary, here the rolling hatches have been opened a little to facilitate a better exchange of air.

Photo 7

Recording the ventilation

Regardless of the mechanism and the ventilation rule is used, taking the decision to ventilate or not requires the regular monitoring and measurement of conditions outside and inside the cargo spaces. Ventilation should also be applied in accordance with carriage instructions provided to the Master and the weather/sea conditions at that time.

Many cargoes that require ventilating to eliminate/minimise the risk of damage from condensation are obviously susceptible to other sources of external moisture, e.g. rain or sea spray. Thus, the risk of exposing the cargo to these additional moisture sources must be considered. Conversely, it is not simply sufficient for the Master to ventilate whenever the weather is “good”. This may not achieve appropriate ventilation in accordance with one of the accepted ventilation rules, since “good” weather could translate to warm and sunny weather, i.e. potentially risking cargo sweat. Given the ventilation rules outlined in this article, it should be obvious that conditions may well be most appropriate for ventilation at night (when temperatures are often lowest).

The conditions should be reviewed regularly, e.g. every 4 hours on a 24 hour basis throughout the voyage. The readings should be taken by the crew and recorded in a ventilation log, along with the actions taken at that time (see an example ventilation log at Table 1). In the event of a cargo claim, such documents can be useful evidence of the appropriateness (or not) of the cargo care regime employed by the crew during the voyage.

Table 1. Example Ventilation Log.

Date	Time	External Dry Bulb Temperature (℃)	Cargo Temperature at loading (℃)	Ventilate?	Remarks
17/01/2016	0000	10	23	Yes	As per Three Degree Rule, ventilate
17/01/2016	0400	11	23	Yes	As per Three Degree Rule, ventilate
17/01/2016	0800	14	23	No	Closed vents, raining
17/01/2016	1200	21	23	No	As per Three Degree Rule, do not ventilate
And so on…					

The limitations of ventilation

It is important to realise that even if properly followed and applied, there are still limitations to how effective cargo ventilation can be. Sweat may still unavoidably form even if the cargo was appropriately ventilated. This may be a consequence of the weather and sea conditions during the voyage and/or the cargo condition. It could also simply be a reflection that conventional ventilation can only really minimise sweat formation in the headspace, with limited impact elsewhere in the cargo space. For bulk cargoes, the vast majority of the cargo will be unaffected by the ventilating air. Regardless, having documentary evidence that the crew gave due consideration prior to loading to the stowage and possible need for ventilation, as well as a record of the decisions and actions taken with regards to cargo ventilation during the voyage, can be of great assistance in defending against claims for cargo damage due to sweat.

With collaboration from Brookes Bell

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