LOSS PREVENTION

Carriage of Bulk Grain Cargoes

INTRODUCTION

Cargoes of 'bulk grain' typically consist of bulk cereals, oilseeds and the value added products and by-products yielded from the processing of both cereals and oilseeds. Cereal grains frequently shipped in bulk or break bulk include rice, wheat, maize (corn), oats, barley, millet, sorghum and rye.

These grains can have end uses in both the food and animal feed sectors. For example, while white maize tends to be used for human consumption, yellow maize will in most cases be used as animal feed. Most poultry farmers include a high percentage of yellow maize in chicken feed as the pigments in yellow maize contribute to the yellow colour of the egg yolk. The quality parameters in bulk cereal grains, including broken grains and foreign matter, will differ depending on whether they are intended to be used for food production or animal feed.

Sound yellow maize destined for animal feed

Processed cereal grains generate value added products. A well-known example of this is flour. Any cereal grain can be used to make flour, however wheat flour is the most commonly shipped and has its final use in the baking industry. While bagged flour tends to be containerised, value added products such as malt barley are also shipped in bulk.

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Cereal by-products are generated during the industrial processing of the grains. These tend to have an end use in the animal feed sector and are processed to contain a specific nutritional composition such as a high protein or fibre content. Corn Gluten Feed Pellets (CGFP) or Dried Distiller's Grains with Solubles (DDGS) are examples of animal feeds that are shipped in bulk.

Corn Gluten Feed Pellets (CGFP) - a by-product of the wet-milling of maize grain for starch (or ethanol) production

Sound Dried Distillers Grains with Solubles (DDGS) which is a bi-product for the ethanol production industry

The bulk oilseed cargoes with which members may be most familiar are likely to include soya beans (also known as soybeans) and sunflower seeds. Soybeans are predominantly processed to extract the oil which can be used either in the food industry or for industrial products such as biodiesel and paint. Soybeans can also be used to make the value added product tofu, a popular high-protein foodstuff. Once oil has been extracted from soybeans, the remaining bean tissue is processed into soybean meal, a by-product which is frequently shipped in bulk for use as animal feed.

Sound soybeans to be used to produce soybean oil for food use and soybean meal for animal feed

The global population may be expected to reach 8.9 billion by 2050 and this will further increase the world's need for cereals and oilseeds. Consequently, the demand for bulk transportation of these cereals across long distances will continue to grow. The different cereals and oilseeds have different biological and physiological properties, which may make their storage or transport difficult. As examples, an increase in moisture content of a grain cargo during a voyage may permit the growth of fungi (commonly known as mould), or the high oil content of soybean cargoes gives them a greater propensity to undergo self-heating during transport. For this reason, the biological properties of these grains should be considered before shipment to reduce the risk of cargo damage during the voyage.

THE IMPORTANCE OF GRAIN MOISTURE CONTENT

Grain cargoes are alive. Even after a grain is separated from the plant, it continues to undergo natural biological reactions including cellular respiration. Respiration is the series of cellular reactions within the grain that result in the production of energy. During respiration each individual grain will absorb oxygen from the atmosphere, combine it with carbon stores and release carbon dioxide, moisture and heat. As biological processes continue, the grain will use up existing energy stores and begin to deteriorate.

The continuation of respiration during the storage and transportation of recently harvested grains can lead to a rapid deterioration in the cargo quality. Water within the grain is essential for these biological reactions to proceed. When water is removed by drying grains, these biological reactions can be slowed and the risk of deterioration can become stabilised for a period of time. There is a specified safe moisture content limit that each type of grain should be dried to in order to minimise the risk of deterioration during storage and transportation. However, this moisture limit is dependent on other environmental factors such as temperature.

Compacted bulk maize cargo as a result of high moisture content at loading

While drying can permit the safe storage of grain for a certain period of time, the grain will still be responsive to any moisture in the surrounding atmosphere. Cereal grains are hygroscopic, meaning that they can release and absorb moisture from the surrounding atmosphere.

The surrounding temperature and the availability of moisture within a grain cargo are the two key factors that determine whether mould growth can be supported. Fungal or mould spores that are naturally present on the grain seed coat can germinate and grow when the relative humidity at the surface of the grain is above 70%, which is mainly determined by the grain moisture content and temperature. Once established, mould growth can cause the degradation of the grain through the breakdown of the grain itself as well as the production of further moisture and heat as a result of mould respiration. This in turn can lead to other portions of the cargo becoming microbiologically unstable. Under specific environmental conditions, mould can produce toxins known as mycotoxins which can have adverse effects on human and animal health when consumed.

Layers of discoloured and compacted corn as a result of high moisture leading to subsequent heating of maize kernels (dark layer) and mould growth (white layer)

Therefore, in order to minimise the risk of deterioration during the voyage, the moisture content of a grain cargo should be as close as reasonably possible to the safe transportable moisture content at the time of shipment. However, this risk persists since large consignments typically comprise smaller parcels of different inherent quality (including moisture) and there will always be those who are tempted to ship grain as wet as possible, in order to sell water for the price of grain.

VARIATIONS IN BIOLOGICAL STABILITY OF CEREAL CARGOES

When bulk cereal and oilseed cargoes are loaded onto a vessel, the total consignment is usually made up of different parcels of grain produced on multiple farms. Each supplier will try to deliver grain with standardised physiology, i.e. grain within the maximum limits for moisture and/or oil content etc. These are normally in line with national standards or contractual specifications that stipulate the acceptable limits for particular quality parameters. However, it is near impossible for growers to deliver grains that are all exactly the same. This is a result of the slightly different environments, e.g. weather conditions, management practices and disease prevalence, experienced by the crops on each farm.

To verify that the parcels of cargo are compliant with the relevant specifications, the cargo is representatively sampled at a specific frequency consistent with an internationally recognized commercial standard and the representative samples are analysed by an accredited laboratory. This can be done on delivery to the smaller storage stations, the terminal and/or during loading to the vessel. When done correctly, it is possible for a known quantity of cargo to be assigned a known quality.

However, it should be noted that the analysis results specified on Loadport Quality Certificates are in most cases an average figure. Therefore, while the average analysis result quoted at the time of shipment may be within the safe transportable limit or contractual specification, a portion of the grain in the stow can be above and below the figure stated. In some cases, subject to the actual figure, this can mean that a portion of the cargo loaded may be expected to be biologically unstable at the time of shipment.

Once the grain consignments from different farms are comingled, typically at inland assembly points and then in turn at the terminal facility prior to loading, the variation in moisture content, oil content and temperature of the different grain consignments can have an impact on the biological stability of the grain during the voyage. Furthermore, some parcels of grain may also be infested with insects when loaded. If allowed to persist in the cargo, insect activity can lead to the establishment of localised pockets of grain with higher temperatures or 'hot spots' as a result of insect respiration causing release of heat and moisture.

Silos commonly visible at export terminals where different parcels of grain are stored together before loading on board

Visible darkening of parts of a soybean cargo indicate that there were "hot spots" of soybeans with high moisture or oil contents which lead to localised areas of damage

Different grain temperatures and insect infestations of grain parcels at loading can lead to variations in temperature across the stow. This in turn can lead to moisture migration under certain conditions and result in the net movement of water. Increases in grain moisture as a result of moisture migration can lead to an increase in biological reactions (such as respiration) within the grain creating suitable conditions for mould growth. Both activities can lead to the release of further heat and moisture, and in due course more widespread self-heating.

This can especially be a problem if the cargo has a relatively high oil content, such as oilseed cargoes like soybeans. Temperatures created from self-heating within soybeans are much higher in comparison to say a self-heating maize cargo, due to the higher calorific value of oil, and can quickly progress to temperatures in excess of 100°C.

Smoking bulk cargo at discharge. In the worst case scenario, high moisture and/or oil contents which lead to self-heating can give rise to potential fire problem

Thus, knowing the safe moisture and oil contents of grains and understanding potential problems associated with these factors is essential. The following section addresses these considerations throughout the transport chain for bulk grain cargoes, with a view to helping to reduce the incidence of deteriorated grain that may lead to unsafe situations on board the vessel including delays, cargo rejection and consequent cargo claims.

LOSS PREVENTION TIPS

1. LOADPORT

Bulk grains are loaded using conveyor belts to transport the grain from the export terminal silo or warehouse to vessel's hold

- Before loading a grain cargo, it should be considered whether the type of commodity being shipped is a "safe" cargo
    - The International Maritime Solid Bulk Cargoes (IMSBC) Code describes which bulk cargoes may be dangerous to carry.
    - While many whole or unprocessed grains are generally not listed in the Code, bulk cargoes including most types of Seed Cake are included.
    - Seed Cake is a schedule within the Code which is divided into sub-categories depending on the Seed Cake production method (solvent extracted or mechanically expelled) and the residual moisture and oil content of the cargo.

Hazardous Seed Cakes are given a Group B classification which describes cargoes which "*possess a chemical hazard which could give rise to a dangerous situation on a ship*". This is a result of any residual oil which may remain in the seed cake by-product after the oil has been extracted.

- The Code gives further advice on the carriage of such bulk cargoes. By-products such as soybean meal and cereal pellets as classified as Seed Cake cargoes

- Forms of Cargo Information for Solid Bulk Cargoes are required to be issued by shippers to the master prior to loading
  - These are issued for cargoes covered by the IMSBC Code, which typically contain relevant information on inherent quality, safety risks and precautions. These forms should be the master's initial point of reference in preparing to load the particular cargo. However, the master should also refer to other accepted industry guidelines, such as Thomas' Stowage or wider industry loss prevention publications, to verify the information stated on the form.
  - Although not covered by the IMSBC Code, these forms may also be issued for whole cereals and oilseeds. This is particularly true for soybean cargoes shipped out of South America, where the forms incorrectly categorise whole soybeans as 'Seed Cake'. In most cases this is not a major problem. However, when an issue arises within a particular cargo, this incorrect classification can give rise to difficult decisions for the master. These commonly include those taken to limit cargo deterioration or prevent an unsafe situation developing on board, especially when the safety precautions or remedial actions advised on the forms/within the Code would not normally be strictly applicable to that particular cargo. These decisions in turn can lead to claims and legal disputes concerning the alleged incorrectness of the actions taken by the master on the basis of the guidelines associated with the incorrectly issued forms.

- Prior to the loading of grain cargoes, adequate cleaning procedures should be undertaken to ensure that the holds are "*Grain Clean*"
  - This level of cleanliness is one of the highest required in the marine shipment of cargoes and generally speaking refers to the holds as being "*clean, swept, washed with freshwater, dry and free from insects, odour or residue of previous cargo*".
  - It includes the removal of remaining residues from previous cargoes and rust from the holds. If the residues are allowed to contaminate the grain, the quality or safety of the cargo may be compromised. Furthermore any water remaining in the hold and bilges after cleaning should be dried/removed to prevent the grain cargo being loaded from absorbing excess water.
  - Holds are routinely washed with seawater before loading grain cargoes, however it is advisable to rinse holds with freshwater before loading grain cargoes to remove any salt residues remaining on the hold steelwork.

Although fresh water is costly, in the event that there is a question concerning seawater ingress during the voyage, there is a possibility that salt residues from seawater washing that come into contact with grain could give rise to positive results for the presence of seawater during subsequent silver nitrate tests (even though the presence of seawater may not necessarily be due to ingress).

- Maintenance of the hatch covers is essential
    - This is to ensure the holds are watertight and that the hatches themselves are fully functional.
    - Additionally, properly maintained hatch covers can prevent significant gas-leakages during fumigation and assist in maintaining the fumigant gas applied at the required concentration during the exposure time.

Ingress of water can occur through the bilge wells or tanks associated with the cargo space

- Prior to loading consideration should be given to grain stowage in relation to heated fuel tanks
    - Heat can be transmitted from the engine room to the aft cargo hold and subsequently affect the cargo loaded against the aft bulkhead. The pattern of damage in cargoes situated close to fuel tanks which have overheated will be obvious as grains will discolour and clump where there has been heat transfer. If possible, stow grain cargoes in holds which will not be affected by heated fuel tanks.
    - Fuel oil temperatures should be closely regulated and recorded during the voyage.

- The documentation of events during loading can be extremely helpful if it is evident that the grain cargo is damaged upon arrival at the disport
    - Taking good quality photographs and keeping an accurate Port Logbook will assist investigations into causation and the extent of damage in the event that a claim does arise.

- Loading should be carried out under the appropriate conditions
    - For example, careful attention to the weather is necessary to reduce the risk that grain cargoes continue to be loaded during precipitation. In this case, loading should be stopped and the hatches should be closed.
    - Wetting the grain cargo during loading can sometimes lead to serious cargo damage during the voyage as a result of increased moisture content giving rise to microbiological activity and self-heating.

- Although an additional expense, representative sampling of the cargo during loading could be helpful in the event of cargo quality disputes
    - Representative composite samples made from incremental samples collected throughout loading are good indicators of the cargo condition at Loadport. If in the unfortunate circumstance that the grain cargo arrives damaged at the disport and a claim is made against the vessel, establishing the condition of the cargo at loading may assist the vessel's defence of any claim.
    - Sampling should be done in accordance with the sampling rules specified on the commercial contract. For example, GAFTA 124 sampling rules for cereals carried under GAFTA contracts or FOSFA guidance for sampling oilseeds carried under FOSFA contracts.
    - The samples should be placed in clean containers, sealed, labelled appropriately and stored at a constant room temperature and out of direct light.

Representative composite samples at loadport can assist in establishing the condition of the cargo at loading

- Before the voyage, masters should be aware of any specific instructions provided by the shipper
    - Shippers routinely provide carriage instructions specific to the type of cargo being carried. For grain cargoes these sometimes include instructions on how to load and stow the grain, as well as providing specific ventilation instructions.
    - If no ventilation instructions are issued by the Shipper, the latest edition of Thomas Stowage or the Lloyds Survey Handbook can be consulted to investigate whether this cargo should be ventilated. If it remains unclear, for the avoidance of doubt, the master/owners should ask the shippers/charterers for specific instructions concerning the ventilation of the cargo during the voyage and any delays.

2. FUMIGATION

- Grain cargoes must be free from live insects and pests on arrival at the discharge port
    - Port Authorities normally require imported grain cargoes to be certified free from live insect pests by Phytosanitary Authorities and it is usually written into the commercial contract that the cargo will not be delivered with a live infestation. Dead insects in the grain on the other hand are usually of no consequence to the Receiver and are normally removed during downstream processing.
    - These phytosanitary considerations are in place to reduce the risk of importing insect pests which could become established in countries previously free from such pests. Furthermore if infested grain is discharged into silos it can be extremely difficult and costly to eradicate the infestation in the handling equipment and storage facilities.

Examples of insect infestations in bulk food cargoes, including soybean meal and corn soya blend that arose after failed fumigations

- Fumigating cargoes after the completion of loading and during the voyage is an effective way to kill insect or vermin infestations already present within the grain
    - If an infestation is allowed to develop during a voyage, not only will the grain sustain damage, but it is likely that the cargo will be rejected by Port Authorities at disport causing delays and incurring further costs.
    - Fumigation is the use of a toxic gas which is capable of dispersing throughout a grain cargo and killing every life stage of an insect or vermin pest without residues of the toxic chemical persisting. Presently the most commonly used fumigant is phosphine. This is a nerve gas, which is applied to grain cargoes in the form of aluminium phosphide or magnesium phosphide tablets. A phosphine fumigation can be carried out in-transit while the crew remain on board.
    - Fumigation at loadport is typically organised by the charterer who will instruct trained professionals to come on board and fumigate the cargo before sailing.
    - It is the responsibility of the vessel to ensure that the hatch covers and holds are sufficiently gas tight to permit a successful fumigation.
    - The responsibility of the fumigator is to ensure that he is satisfied the holds are gas tight to permit a safe fumigation, and for this he inspects the hatches prior to fumigating. The fumigator will advise on the necessary safety equipment required on board, carry out inspections of the hold before fumigation as well as issue instructions on venting the fumigated holds after a period of exposure.

- It is of paramount importance that crew take safety precautions seriously and follow any instructions issued by the fumigator
    - During the fumigation, the fumigator is in charge for the safety of all those on-board during a fumigation at loadport and in-transit fumigation.
    - As mentioned, phosphine is a nerve gas and does not target insects specifically but can kill humans too.

Crew members should wear the correct safety apparatus advised by the fumigator. Crew member taking sample of cargo before discharge whilst wearing a mask to protect against any residual phosphine gas. Powder residues from the fumigant tablets applied at loadport are visible in the foreground of the photograph.

Fumigation powder residues visible on the cargo surface

- Photographs of the method of fumigant application and pattern of application can be useful, if they can be safely taken by the crew (e.g. from the bridge)
    - Phytosanitary Authorities will normally declare a cargo pest free providing that it has undergone fumigation and they have been provided with proof of the event.
    - Successful fumigations rely on the complete dispersal of the fumigant gas at the required concentration throughout the hold and for the required period of exposure time. Fumigators will calculate the dosage rate and the duration of the exposure period based on the volume of the holds, the temperature and the depth of cargo loaded. The correct dispersal of the gas is also partly dependent on the method of application.
    - These details will be documented on a Fumigation Certificate and/or a booklet of Fumigation Documentation issued by the fumigation service to the master.

Metal storage canisters used for phosphine fumigants before application

Fumigation slings or socks containing fumigant tablets are placed on the cargo surface before sailing

FUMIGATION LEGISLATION UPDATE

The Use of Methyl Bromide in Pre-Shipment Fumigation:

While phosphine is presently the most widely used fumigant in the maritime sector, methyl bromide has previously been used for many years.

Methyl bromide is an ozone-depleting chemical which was primarily used as a quarantine pesticide for soil, wood and grains. It is fast acting and fumigation exposure times can be as little as 24 hours, however in-transit fumigations with methyl bromide are prohibited for safety concerns and the crew must also leave the vessel in the event that a methyl bromide fumigation is undertaken at the berth. This can incur additional costs associated with accommodating the crew and lead to concerns for owners and charterers about the safety of their vessel during this time.

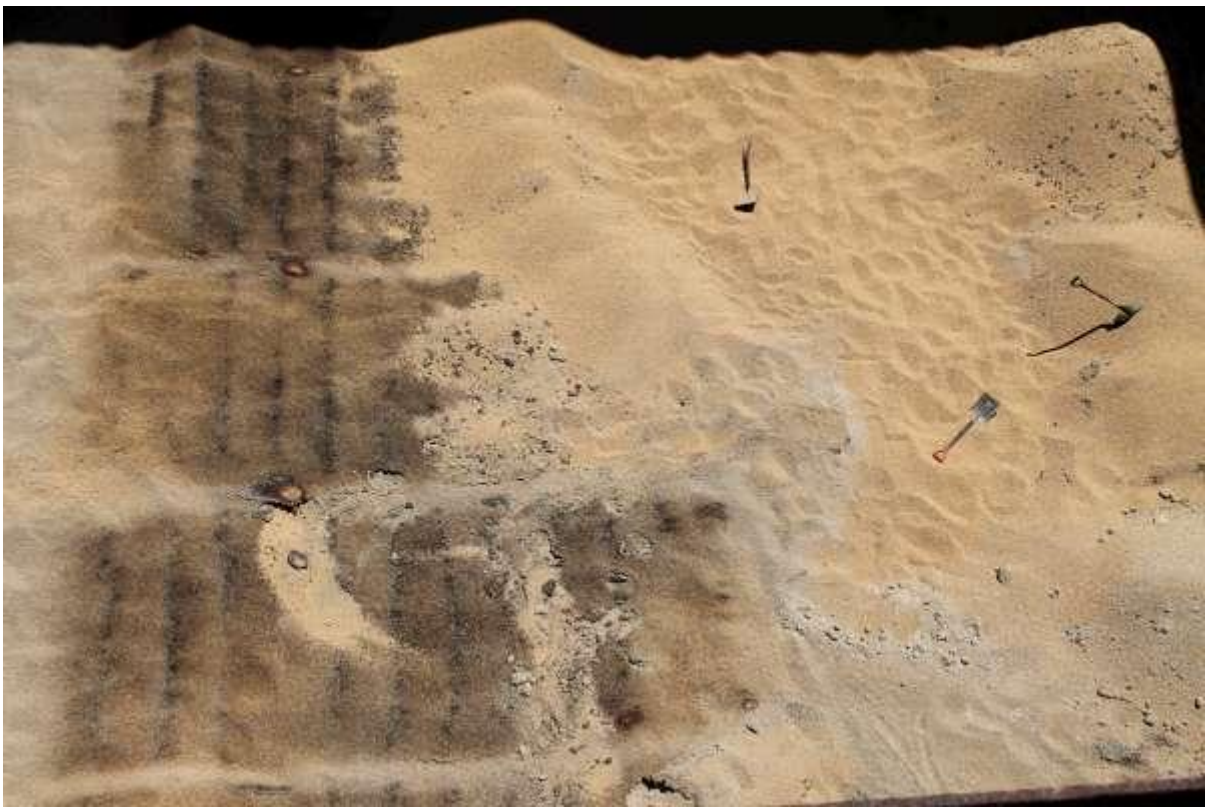
In 1992, the Montreal Protocol described the initial strategy to phase-out the use of methyl bromide as a pesticide. This strategy was agreed by 160 countries. All developed countries agreed to a complete phase-out of the chemical as a pesticide by 2005, while 2015 was the phase out date set for developing countries. Quarantine, pre-shipment and critical uses of methyl bromide were totally prohibited in the USA, UK and EU by 2010. While the phase-out of methyl bromide should be 100% effective in developing countries as of 1 January 2015, quarantine, pre-shipment and critical uses of methyl bromide may be still permitted in certain circumstances.

3. VENTILATION PRACTICE

- Appropriate ventilation of the grain during the voyage reduces the risk of ship and cargo sweat formation
    - Cargo sweat is when condensation forms on the surface of the cargo and ship sweat is when condensation forms on the steelwork of the hold and may drip down onto the surface of the cargo. Both increase the moisture content at the surface of the stow. This increases the risk of self heating and mould growth. Ventilation plays a part in reducing these risks.

- Ventilation of grain cargoes should be applied as and when appropriate
    - The cargo should be ventilated in accordance with maritime ventilation practice, with carriage, voyage or fumigation instructions, and when weather and sea conditions permit.

- Masters will most likely be familiar with the Three Degree Rule or the Dew Point Rule which provide guidance on when grain cargoes should be ventilated.
- While the Dew Point Rule is a valid method of ventilation it involves determining whether the dew point of the air inside the hold is higher than the dew point of the air outside the hold. If the holds are sealed then gaining accurate dew point measurements of the headspace in the hold is challenging.
- For this reason the Three Degree Rule is a more practical ventilation method to employ. When following this rule, a grain cargo should only be ventilated if the dry bulb temperature of the air outside the hold is 3°C or more, cooler than the average cargo temperature at loading. For this rule to be applied accurately during the voyage, multiple measurements of cargo temperature should be taken at various points across the cargo surface for each hold at the completion of loading. An average surface cargo temperature for each hold should then be calculated.



Bulk cargo which has sustained damage from ship sweat is visibly damaged once the hatch covers are opened at disport. Condensation has dripped down the panels of the hatch covers resulting in the grid pattern of damage. The damage is superficial as the stevedores are able to remove the top layer of damaged cargo to reveal sound cargo just underneath.

4. DISCHARGE

Bulk cargoes tend to be discharged by grabs into trucks

Trucks then transport discharged grain to the Receivers facilities. Some grain terminals receive grain into an intake pit which is then moved by conveyor belt into a silo store.

- Before discharge of grain cargoes can be approved, holds that have been subject to fumigation will have to be declared Gas Free
    - This is to ensure the holds are free from any gas that may make the holds unsafe.
    - Oxygen levels must be allowed to return to ambient levels to allow a safe working environment for crew and stevedores. The acceptable limits for specific gases that allow "Gas Free" to be declared may vary from country to country.

- After the holds have been declared Gas Free, the surfaces of the cargo may be subject to a visual inspection
    - This can be carried out by the Receiver, Port Officials and/or Government Inspectors as the hatches are opened, prior to the approval of discharge.
    - In some countries, indicative samples are taken and analysed to confirm the decision taken up to that point on the basis of the visual inspection.

- Discharge should be carried out under dry conditions
    - The vessel is still responsible for the grain until it is over the rail and off the vessel. The vessel may be liable for damaged cargo if discharge is continued during rain and cargo within the holds became wetted.

- Obtaining representative samples throughout discharge could assist in settling later cargo quality disputes
    - As with loading the cargo, samples taken throughout discharge according to official sampling rules give an indication of the quality of the cargo at discharge.
    - Each party involved in the commercial transport of the cargo should consider appointing an independent cargo inspection company to obtain representative samples. This can be done jointly to reduce costs.

Taking samples of the surface and representative samples of a cargo of bulk maize before discharge can assist in establishing quality of the cargo

- It is important to ensure all document is available for the importation of the cargo before arriving at the disport
    - A principle consideration for the discharge of bulk grain cargoes is to ensure that the appropriate documentation is available for the importation of the cargo.
    - The importation documentation and requirements will vary from country to country, however these are primarily the concern of the shipper.

PROBLEMS THAT MAY BE ENCOUNTERED AT THE DISPORT

1. Visible damage to the cargo

- Documenting the nature, pattern and extent of any alleged damage is invaluable in assisting the investigation into cargo damage.
- High quality photographs taken by the crew will be helpful in this regard, as well as detailed notes on the location and size of the areas of damage, the colour of damaged grain and any odour associated with the damage.

2. Visible mould damage to the cargo surface

- If there has been some form of cargo or ship sweat during the voyage, mould growth may be visible on the surface of the cargo as the hatch covers are opened.
- Furthermore, compacted cargo which is mouldy may also become visible as discharge continues.
- The presence of visible mould does not always indicate that mycotoxins will be present in the grain, however it further emphasises the need to ensure that the grain is safe for consumption if that is the intended use.
- Depending on the extent of the damage it may be necessary to sample the cargo representatively according to the national regulation of the importing country or failing that according to agreed international standards.

Visible mould growth and extensive heating damage to the surface of a cargo of soybeans prior to discharge

3. Segregation of sound and unsound grain

- In the unfortunate circumstance that damage is observed during discharge, all parties involved have a duty to mitigate the damage.
- It is important that visibly damaged grain is segregated as much as possible from sound cargo, to quantify the amount of damage and to limit unnecessary damage to sound cargo.
- In the event that other parties are not cooperating to mitigate any damage, the master should issue a Letter of Protest.

This cargo of heated soya bean was segregated into different piles according to the type and degree of damage. Segregation took place on the berth during discharge.

4. Stevedore handling and pilferage

- In certain ports it is common to observe pilferage of the cargo by the stevedores.
- Crew should document any pilferage and limit it as much as is safely possible to do so.

CONCLUSION

There are many considerations to be taken into account when shipping sensitive bulk cargoes, such as cereals or oilseeds. Each different commodity has different physiological characteristics that make the duty of care slightly different in each case. While a grain cargo maybe within contractual specifications, parts of the stow may be biological unstable and understanding these grain cargoes and how they may behave during the voyage may assist in preventing cargo damage which may arise during the journey.

CREDITS

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