Insight Article

Shifting solid bulk cargoes

AN EXPLANATION OF THE PROCESSES AND DANGERS

Solid bulk cargoes can shift by sliding or liquefying, and whilst the factors involved in each of these processes are different, the potentially disastrous consequences are the same, listing or capsizing and/or structural damage.

Dense cargoes, e.g. ore concentrates, have by definition a relatively high mass to volume ratio, so even a small amount of shifted cargo can have a large mass. Coupled with the momentum generated by a moving vessel considerable forces can act upon the ship's structure. This force will be even greater when the cargo level within the hold is above the sea level outside the hold, so that the counter-acting force of buoyancy is absent. Add to this the frequent occurrence of multiple or repetitive shifts and the result can be excessive plate flexing increasing the risk of cracking and failure.

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In terms of stability, shifting cargo can have numerous consequences. The shift in cargo will cause a list if the cargo does not return to its original position with subsequent vessel movement. Apart from increased draft concerns, the angle at which the vessel is listed will, if uncorrected, become that about which the vessel rolls. This will usually mean that the righting lever for angles of heel towards the side the vessel is listed will be less than that when the vessel is heeled from her upright position, which in turn means that the force returning the vessel from angles of heel beyond the angle of list, back to the same angle, will be less than the force returning the vessel to the upright had she not been listed. The angle of deck edge immersion will also be closer than that for an upright vessel and if this is reached stability will also be reduced. A list will also tend to subject the vessel to greater angles of heel and this may give rise to a domino effect causing other cargo and objects to break securings and/or to shift. Solid bulk cargoes that shift from one side of the vessel to the other with the rolling of the vessel, that is to say, cargoes behaving like a liquid in a part-filled tank, will also give rise to a Free Surface Effect, and this again will reduce the vessel's stability in a similar way to that described above. The gravest consequence of shifting is capsize of the vessel, and this can happen when multiple shifts occur with little return of cargo to original positions. This process can be very quick and obviously disastrous.

Sliding occurs when the cohesive strength, or "stickiness" of the cargo, is insufficient to withstand the effects of rolling. Cohesive strength varies according to moisture content and the height of the stockpile. A good illustration of this is provided by sand. Wet or dry there is a limit on the height of a pile of sand, but damp sand tends to permit a higher sand pile. A common example of a cargo prone to sliding is grain, which is particularly free flowing. The International Maritime Organisation (IMO) Code of Safe Practice for Solid Bulk Cargoes 1991 states (at para 5.2.4.2) that "non-cohesive bulk cargoes having an angle of repose less than or equal to 30 degrees flow freely like grain and should be carried according to the provisions applicable to the stowage of grain cargoes". The stowage and carriage of grain is governed by the IMO Grain Rules 1982 which set out a number of requirements including specific stability criteria. There is also some industry authority to support a theory that sliding can also occur when, due to downward moisture migration, a saturated base layer (which need not be liquefied) is formed allowing the upper, relatively drier layer, to move against it.

Liquefaction of solid bulk cargoes depends on particle size and distribution as well as moisture content. The former determines whether moisture can drain freely through the cargo, and will obviously change during a vessel's voyage due to vibration, rolling, pitching and twisting. The effect of this movement is to break down lumps of cargo and reduce the space between particles, effectively compacting the cargo. Moisture can then become trapped between cargo particles and if there is sufficient saturation a flow state can develop. The point at which this occurs is called the Flow Moisture Point (FMP) and is usually expressed as a percentage of the moisture content. The IMO Bulk Cargo Code referred to above adopts what is known as the Transportable Moisture Limit (TML), and this is the maximum moisture content of a cargo deemed safe for carriage by sea in ships other than "specially designed ships". It is defined as 90 per cent of the FMP. Cargoes prone to liquefaction are those with a small particle size and those which contain moisture as a result of the way they are processed before loading, e.g. iron ore concentrates and coal slurry or duff4.

It is perhaps worth mentioning here that solid bulk cargoes are increasingly being carried in Intermediate Bulk Containers (IBC)5. The Association's experience with this type of carriage suggests that the dangers of shifting cargo can be just as real. Solid bulk cargoes which are prone to sliding have been known to force the sides of even rigid IBC's to move and if there are gaps within the stow, or the sides of the stow are insufficiently shored, a general collapse of the stow can occur.

A CASE EXAMPLE - LIQUEFACTION OF SCALE DUST

An increasingly common solid bulk cargo is dust, commonly originating from industrial chimneys. Industry has for some time been required to limit the pollutants discharged into the environment and to this end chimneys can be installed with filters. The material collected by these filters is generally termed filter dust; material which builds up on the inner chimney surfaces also gives rise to another type of dust; scale dust. The contents of these substances vary enormously and chemical hazards are often associated with them. This is one of the reasons why many societies in our greener world no longer allow them to be left stored and forgotten on open slag heaps or in land-fill sites. The option to be considered in many of today's societies is re-cycling and it is this which has, to some extent, led to the water transport of dust. The problems and dangers of watery filter dust were last mentioned in Gard News Edition 1046, and a recent case involving scale dust suggests to us that these problems and dangers are not fully understood and that essential precautions are not being adhered to. The vessel in question loaded at Algeciras, Spain, and the scale dust in bulk was to take up most of her centre hold. The majority of the scale dust was noted by the master to be in open storage on land, unprotected from the elements, and on closer examination, was found to have a high moisture content in parts. Whilst the master was concerned as to the state of the cargo, loading commenced, and since this took place during periods of rainfall, moisture levels increased. No documents were produced by the shippers to record the properties of the scale dust, and when the master did raise concerns with the various cargo interests, including their surveyors, he was told that the loading of the cargo during rain, and the wetting of the cargo, was normal and of no importance with regard to the quality of the cargo. The loading of the cargo seemed to be completed without further event or protest and clean bills of lading were issued. On the loaded passage the vessel encountered moderately heavy weather, causing heavy rolling and pitching at times. Four days into the passage a series of splashing and banging noises were heard which seemed to come from the hold containing the scale dust. Inspection of this hold revealed that the scale dust had become fluid and was splashing violently against the hold sides. The inspection itself was not without danger as a 5-6 metre geyser erupted from the booby hatch opened for inspection. The resultant mess on the ship's superstructure was the least of the worries facing the master as shortly afterwards the vessel took on a list. Fortunately the vessel was able to compensate for this by careful and strategic ballasting and was able to reach the discharge port without further serious incident. Further inspection at the discharge port revealed that the forces involved with the shifting of the liquefied scale dust had resulted in the penetration of the cargo into an adjacent hold under and above a moveable transverse grain bulkhead. Problems ensued with the consignees who held the vessel liable for loss and damage to the cargo and the extra costs of discharging and storing the fluid cargo. The surveyors appointed by the owners learnt that the surveyors appointed on behalf of shippers, had issued a "certificate" of the moisture content at the loading port and given this to the consignees, but not to the master. The certified moisture content was said to be in the region of 11 per cent but tests at the discharge port determined a moisture content of nearly double this figure.

LESSONS LEARNT AND PRECAUTIONS TO BE TAKEN

It is perhaps fair to say that the above vessel was fortunate to have completed her voyage without more serious incident. Having read the case summary, the reader will probably be able to find a number of areas where essential additional precautions could have been taken. Outlined below are a number of points which should be considered when contemplating the loading of solid bulk cargoes suspected of having a propensity to shift. (1) Carry out a visual examination of the cargo and enquire as to the extent and duration of exposure to moisture (unprotected stowage on wet ground or in wet weather). (2) Obtain and keep safe ship's own samples (the quantity should be sufficient for any necessary tests and be properly labelled and recorded etc). Do not just accept shippers' samples, unless these are taken in your/ your representatives' presence. (3) Request in advance of the vessel's arrival, the shippers' declarations with regard to FMP, stowage factor, TML, moisture content, angle of repose, any chemical hazards and details which may require safety precautions to be taken. If such documentation is not forthcoming it should be demanded and a letter of protest to shippers and charterers should be issued. The master can and should refuse to load the cargo if the documentation is still not forthcoming8. Remember that each individual cargo is unique. Details of cargoes previously carried, even if from the same origin, should not be relied on. (4) Check the details of the shippers' declaration carefully. The details should be accurate at the time the certificate is issued and the combination of a pre-dated declaration and suspected exposure to further moisture since the date of the certificate should raise concern. Some ports have rain gauges to assist in the quantitative assessment of the effects of rainfall on moisture content after certificates have been issued. If suspicions are raised, the shipper should be requested to perform the necessary tests. In any event, loading should not commence again until the vessel itself is satisfied that the cargo can be transported. It may be necessary for the ship to perform its own tests. Do not be led astray by shippers proclaiming that all is fine and normal and that the cargo quality will be unaffected. This is not a quality issue, it is a safety issue. (5) In any event, cargoes with a moisture content above the TML should not be shipped. Remember that it may only be necessary to reject parts of the cargo, but this should raise concern as to the safety of the remaining cargo. (6) The cargo space should be filled as much as is practicable, but always within stability, stress and deck loading constraints. A part-filled compartment is more prone to shifting and has greater space in which to allow shifting. (7) Longitudinal separation (e.g. temporary bulkheads), and overstowing (e.g. bulk bundles) can be effective in limiting the distance cargo can shift, the shift amount and forces involved. Expert advice is recommended to ensure that these measures are appropriate. In addition, overstowing may not be appropriate, and shifting forces are often underestimated thus risking the failure of longitudinal separation. (8) Cargo stows should be trimmed level right out to all sides of the cargo compartment. It is appreciated that trimming has its disadvantages, e.g. increased time and cost at load and discharge ports. However, it has more important advantages. Apart from reducing the possibility of cargo shift, weight distribution and stability are improved. (9) Do not stow other cargoes containing moisture in same compartment. (10) Do not load during rain. If this cannot be avoided have the moisture content re-tested to ensure that it complies with point 5 above (it should be noted that some cargoes can be damaged by exposure to moisture). (11) If possible, adjacent tanks to the compartment concerned should be empty. If they cannot be made empty, extra care should be taken to ensure that watertight integrity is intact. This recommendation also applies for the whole compartment; hatch covers in particular should be closely examined and tested (hose/chalk/day light tests). (12) The vessel should not be too stiff in terms of her stability as this will cause the vessel to roll quickly and perhaps violently. In saying

this, the vessel needs an adequate metacentric height taking into account all the various factors which can lead to a reduction in this during the voyage. (13) Bilges should be clean and empty, strums or rose boxes should be clear and lumber boards, where fitted, should be intact. Bilge well grilles should be covered with burlap. The pumps and bilges should be tested in all respects (particularly alarms and non-return valves) prior to loading. Soundings are to be taken at regular intervals during the voyage and bilges pumped as necessary. Concerns as to the effect of cargo weight loss due to moisture removal are understood, but again there are more important concerns. To protect owners' position it is recommended that a record is made of the amounts of moisture removed via the bilges, and this can be done by soundings. (14) Weather routing is recommended in order to avoid heavy weather and/or sustained periods of it. (15) Always consult the relevant IMO/flag state/port state/company codes/guidelines/ recommendations. Port states in particular may impose stricter rules than those adopted internationally, e.g. with regard to the TML. (16) If in doubt and assistance is needed, the Association is always on hand. In conclusion, shifting solid bulk cargoes can be costly, not least in terms of money, but people's lives. The dangers are real and are not to be ignored; precautions need to be adhered to.

Footnotes

1. For a guide to the basic principles of transverse stability (including definitions used in this article) please refer to the article in Gard News Edition 145, March 1997 (pages 14-18).

2. The term grain includes wheat, maize, oats, rye, barley, rice, pulses and seeds.

3. The angle which the cargo naturally, and of its own accord,makes with the horizontal.

4. The IMO Code of Safe Practice for Solid Bulk Cargoes 1991 (as amended) lists some commodities which may liquefy.

5. An IBC may be described as a disposable or re-usable receptacle designed for the carriage of bulk commodities in parcels of 0.5 to 3.0 tonnes. They can be of rigid (e.g. fibre board) or flexible (e.g. bags) construction.

6. December 1986 (page 13).

7. As of 1st January 1994 it became a SOLAS requirement for the shipper to provide this type of information.See International Convention for Safety of Life at Sea 1974 (as amended) Chapter VI, Part A and specifically Regulation 2.

8. Charterers are obliged to load only safe cargoes and without the necessary documentation this can not be determined. Laytime disputes may arise and it is recommended that charterparties expressly stipulate that time lost due to non-production of the necessary documentation and/or due to reasonable measures taken by the ship where the accuracy of document details is reasonably suspected, is to be counted as laytime. Diversion to a port of refuge may also be necessary and it is recommended that charterparties make provision for charterers to bear the costs and consequences of this where caused without the owners' negligence.

9. The IMO Code of Safe Practice for Solid Bulk Cargoes 1991 sets out the tests and procedures.