LIQUEFACTION OF IRON ORE FINES WITH CASE STUDIES

By : Capt. John P. Menezes – FNI, FICS, MCMS
Mangalore, India.

1. Liquefaction:

Liquefaction strikes a chord with refrigeration, which is conversion of vapour into liquid, thermally. However, in current context, it implies conversion from non- flowable state to flowable state mechanically within 'angle of repose' envelope and is reversible, evidently requiring presence of liquid (water/moisture).

2. General aspects:

As liquids propel lumps, only fines suffer liquefaction.

Liquefaction is not intended in trade and surface transportation. However, it is intended in pipeline transportation and processes. Further, finished products like bulk cement etc would not contain moisture and only raw material like ores would contain moisture and suffer liquefaction.

Water originates from extraction, enrichment and rains. Although density differences enable separation readily, due to cost and infrastructure reasons, total elimination or 'low-no risk' levels of moisture cannot be achieved.

3. Mechanics of liquefaction:

Liquefaction is caused by separation of moisture content and some kind of separated water-fines mixing.

3.1 Ashore:

Mechanics are simple and not significant as liquefied cargo would just drain out without snowballing. Cohesive water is retained. The surplus water which surfaces, drains out as free water or slurry.

Rain water does not penetrate to the core and forms its own gutter for gravitating to ground.

3.2 Ship-holds:

Mechanics are rather complex with water draining into hold bilges and mixing prospects with Cargo due to ship dynamics (vibration/weather).

With conditions conductive to draining into bilges and pumping thereof, liquefaction unlikely. However, with condition unfavourable, separated water migrates to surface and forms scattered puddles. This, results in lower strata compaction with increased draining resistance and loose surface cargo with presence of water.

Depending on mode and speed of loading, cargo geometry can have multiple peaks and plateaus.

4. Liquefaction initiation:

The main factors are high moisture content and water draining. The monsoon factor is nominal as loading is stopped during rains and exposure limited to hatch cover area. Multi-purpose ships with lift-away pontoons take more time to close hatches than modern bulkers with folding hatch covers.

Small lists due to rolling/deballasting create surface water flow, truncating peaks/collapsing cargo, resulting in huge dangerous moments.

5. Trade impact:

The trade involves, pre-shipment part, shipment part and post shipment part.

Being marine platform, article restricted to shipment part. Shipment consists of loading, carriage and discharging.

Liquefaction adversely affects shipment part commercially/operationally.

By and large, it is initiated at load port, aggravated during voyage and may persists during discharge.

6. Problems and effects during various phases:

6.1 Loading:

Ore Fines loading rates being high, there is lack of time for timely detection, corrective measures etc.

The basic modes of loading are by conveyor-chute or grabs (rarely slings). The cargo geometry is influenced by loading mode and can lead to conditions conducive to liquefaction.

Contributed by unsatisfactory draining, it can cause delayed upward water migration appearing on the surface during voyage or prior departure during longer port stays.

These puddles cannot be pumped out with portable pumps also and may require exposure to weather.

Pressure of time can affect prudent decisions.

Casuality prospects virtually nil.

Scope for minor claims involving delays, quantity and quality (Effect).

6.2 Passage:

Depending on conducive conditions liquefaction can ensure in few cases. The liquefaction, can lead to severe casualties beyond ship’s control. Adverse weather can be contributory. Scope for major claims (Effect).

6.3 Disport:

Discharging is normally by grabs. Grab handling of liquefied cargo evidently difficult. Prospects of casuality poor. Scope for nominal claims towards delays, quantity and quality (Effect).

7.0 <u>Ascertaining liquefaction prospects:</u>

The main lab parameters are Flow Moisture Point, Transportable Moisture Limit and Moisture content, which evidently cannot be carried out on board. Lab tests take time and facilities may not be available at load port (for FMP and TML).

Thus, options are to rely on Shippers quality certificate without delaying cargo operation and 'on site' (field) checking.

The 'on site' checking is by visual inspection and 'can test'. Can test involves stage-wise representative sampling of hold cargo and visual inspection tends to be continuous, rather difficult with multi-point loading.

However, by deft combination of both, quality can be monitored and controlled.

A post-loading check is the monitoring of hold bilges subject to satisfactory burlapping/water draining. With 'pre-shipment' analysis in advance, 'on-site' checking with 'Can Test' and monitoring of hold bilge soundings, a clear picture of cargo would emerge and liquefaction can be avoided.

8.0 <u>Generation of claims and resolution of liability:</u>

In the light of effects, in section 6 scope for claims exist.

The claims arising in load port and disport are easier to resolve as Surveyors would be available at hand for various cargo interests and claims would be in the low range.

The claims arising during voyage tend to be substantial and may attract general average, which can be resolved only by accurate records of Vessel.

9.0 <u>Prudent measures related to Vessel:</u>

- Satisfactory hold bilge pumping in Port/Sea.
- Adequate burlapping of hold bilge covers.
- Ensure Hold Bilge covers secured to prevent shifting.
- Regular monitoring of hold bilge levels.
- Inspection of cargo during loading, upon sailing and monitoring through hold accesses for water slurry etc.
- Multi-purpose Ships have 'lift away' type hatch covers and to be discouraged.
- Prevention of water ingress either through hatch covers or ballast system or hold bilge line reverse flow.
- Proper trimming of cargo.
- Pumping of hold bilges is subject to local regulations and issue to dealt with in advance. It stands to reason that origin of water being from cargo pumping out same would not be objectionable. Drained out water tends to be colorless.
- Pre-loading hold survey should specifically ascertain hold bilges sealing and hold bilges pumping.
- Strictly follow Code of Safe Practice for loading Bulk Cargoes.

10.0 <u>Case Study:</u>

10.1 Background:

The two case studies involved were on the South West Coast of India.
Thus, an overview of regional geography, weather, quantity, quality, background is warranted.

The main mineral of this region is Iron Ore and region extends from Goa through Karwar, Belekere, Port Redi, and New Mangalore.

Of these, Belekere, Port Redi are seasonal anchorage loading ports.

Goa, is all-weather deep draft berth port with conveyor, and seasonal outer anchorage loading with transhippers/fed by cargo barges. New Mangalore is all weather berth port.

Karwar is all weather shallow draft berth port and anchorage loading to deeper draft during season/final loading at New Mangalore off-season. The region experiences heavy rainfall during (mid May to mid September) season with beginning/end of season as per Indian Meteorological Department.

Till 2005, the export was mainly handled by Kudremukh Iron Ore Company Ltd. (KIOCL) from New Mangalore and leading mine Owners of Goa.

The Iron Ore for KIOCL is from Kudremukh mine heads (about 100 KMS from Mangalore hinterland). As Iron Ore is poor quality, it is washed and converted to concentrated Iron Ore slurry for pipeline transportation to New Mangalore facility. At New Mangalore facility, after water separation and weathering solid Iron Ore concentrate was loaded into Ships with 4000 MT/hour conveyor facility deep drafted 12.5 MTRS dedicated berth at New Mangalore Port.

Despite transportation as slurry, there was not a single casuality for over 30 years due to cargo in general or liquefaction in particular.

The closure of KIOCL due to ecological reasons in 2005 coincided with Chinese boom and rise of private exporters.

The liquefaction incidents occurred only during Chinese boom and private Shippers.

KIOCL was a big Public Sector company with in-house lab/sample and large quantity available for blending. With long tradition of exports, Goa Mine Owners were better oraganised. The ‘noveau’ private Shippers were neither traditional mine Owners nor land infrastructure, they were mere traders. Charterers too sprung up from Calcutta, Mumbai, Singapore, and Hong Kong. It was question of cutting corners and staying competitive.
In such a scenario, all aspects of trade tend to be safe in letter than spirit.
The similarity between both case studies was loading during monsoon.

11.0 **Analysis of Case Study**:

The case studies are dissected in depth from following perspectives:

- Whether the casualty could have reached disaster proportions.
- Whether it could have been prevented.
- Whether it has resulted in some awareness in the Trade and Ship carriage.
- Whether, additional steps are warranted over and above existing Codes and Practices.

The incident did not reach disaster levels due to proximity of Vessel to Coast and appropriate post incident action.

It could have been avoided by exercising due diligence by all concerned (viz Shippers, Vessel and Port).

The responses to incidents were rather complacent and casual, rather 'Knee jerk' reaction in nature.

Till date, there have been no concrete steps from the trade in this direction.
As far as Ship related part is concerned, the present codes/practices are effective, which has to be implemented prudently in full measures.

Abundant caution, imperative in the pre-loading phase.

This can only be achieved by improving the mindset of Shippers in terms of track records and reputation.

Trade should have long term approach in establishing safety standards towards accident free image rather than profitability alone.

Dt. 15th June 2009